LISTING BACKGROUND DOCUMENT FOR THE 1992-1996 PETROLEUM REFINING LISTING DETERMINATION

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1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Environmental Protection Agency's (EPA's) Office of Solid Waste (OSW), as directed by Congress in the Hazardous and Solid Waste Amendments of 1984 to the Resource Conservation and Recovery Act (RCRA), has undertaken an investigation of the Petroleum Refining Industry. This investigation was also mandated by a 1994 consent decree resulting from litigation brought by the Environmental Defense Fund (EDF). The consent decree identifies 14 specific residuals for which the Agency must make listing determinations and an additional 15 residuals that the Agency must study. These 29 residuals, subsequently referred to as the Residuals of Concern (RCs), are listed in Table 1.1. As a result of the consent decree, the Agency embarked on a three-year project to determine whether these 29 RCs pose a threat to human health and the environment and to develop a basis for making such a determination. This background document presents the information collected to support the 14 listing determinations.

The Petroleum Refining Industry was previously studied by OSW in the 1980s. This original effort involved sampling and analysis of a number of residuals at 19 sites, distribution of a RCRA §3007 questionnaire to 180 refineries (characterizing the industry as of 1983), and, ultimately, a listing determination effort focused on wastewater treatment sludges, culminating in the promulgation of hazardous waste listings F037 and F038 (respectively, primary and secondary oil/water/solids separation sludges from petroleum refining).

As part of the Agency's current investigation of residuals from petroleum refining, the Agency conducted engineering site visits to 20 refineries to gain an understanding of the present state of the industry. These 20 refineries were randomly selected from the 185 refineries operating in the continental United States in 1992. Familiarization samples of various residuals were collected at 3 refineries to obtain data on the nature of the RCs and to identify potential problems with respect to future analysis. The Agency then conducted record sampling and analysis of the RCs. During the record sampling timeframe, an additional 6 facilities were randomly selected to increase sample availability. Approximately 100 record samples were collected and analyzed. Concurrently, the Agency developed, distributed and evaluated a census survey of the industry. Science Applications International Corporation (SAIC) (EPA Contract No. 68-W4-0042) has been contracted to assist EPA/OSW in the characterization and evaluation of these residuals.

Table 1.1. Petroleum Refining Residuals Identified in the EDF/EPA Consent Decree

Sludges\Sediments:

Clarified slurry oil sediments and filter solids from catalytic cracking (L) (CSO sludge)

Unleaded storage tank sediments (L)

Crude storage tank sediments (L)

Process sludge from sulfur complex and H₂S removal facilities (L) (sulfur complex sludge)

Sludge from HF alkylation (L)

Sludge from H₂SO, alkylation (L)

Desalting sludge from crude desalting (S)

Residual oil storage tank sludge (S)

Process sludge from residual upgrading (S)

Catalysts:

Catalyst from catalytic hydrotreating (L)

Catalyst from catalytic reforming (L)

Catalyst and fines from catalytic cracking (L) (FCC catalyst and FCC fines)

Catalyst from catalytic hydrorefining (L)

Catalyst from H₂SO₄ alkylation (L)

Catalyst from sulfur complex and H₂S removal facilities (L) (Claus and tail gas treating catalysts)

Catalyst from extraction/isomerization process (S)

Catalyst from catalytic hydrocracking (S)

Catalyst from polymerization (S)

Catalyst from HF alkylation (\$)

Off-Spec Products:

Off-spec product and fines from thermal processes (L)

Off-spec product and fines from residual upgrading (S)

Off-spec product from sulfur complex and H,S removal facilities (S)

Treating Clays:

Treating clay from clay filtering (S)

Treating clay from lube oil processing (S)

Treating clay from the extraction/isomerization process (S)

Treating clay from alkylation (S)

Miscellaneous Residuals:

Spent caustic from liquid treating (L)

Off-spec treating solution from sulfur complex and H₂S removal facilities (S)

Acid-soluble oil from HF alkylation (S)

L: Requires listing determination as per the EDF/EPA consent decree.

S: Requires study as per the EDF/EPA consent decree.

1.2 EXISTING PETROLEUM REFINING LISTINGS

As a result of past listing investigations, the Agency previously promulgated a series of listings that apply to the petroleum refining industry. These listings are associated primarily with the refinery wastewater treatment systems. The consent decree residuals, in contrast, are not wastewater treatment residuals, although some of the residuals of concern are typically managed in the refinery wastewater treatment plants. The existing listings are described below:

Hazardous Waste Listing	Listing Description					
K 048	Dissolved air flotation (DAF) float from the petroleum refining industry (T)					
K049	Slop oil emulsion solids from the petroleum refining industry (T)	5/19/80				
K050	Heat exchanger bundle cleaning sludge from the petroleum refining industry (T)					
K051	API separator sludge from the petroleum refining industry (T)	5/19/80				
K052	Tank bottoms (leaded) from the petroleum refining industry (T)					
F037	Any sludge generated from the gravitational separation of oil/water/solids during the storage or treatment of process wastewaters and oily cooling wastewaters from petroleum refineries. Such sludges include, but are not limited to, those generated in: oil/water/solids separators; tanks and impoundments; ditches and other conveyances; sumps; and stormwater units receiving dry					
	Sludges generated in stormwater units that do not receive dry weather flow, sludges generated from non-contact once-through cooling waters segregated for treatment from other process or oily cooling waters, sludges generated in aggressive biological treatment units as defined in §261.31(b)(2) (including sludges generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and K051 wastes are not included in this listing.					

Hazardous Waste Listing	Listing Description	Date of Pub.
F038	Petroleum refinery secondary (emulsified) oil/water/solids separation sludge - Any sludge and/or float generated from the physical and/or chemical separation of oil/water/solids in process wastewaters and oily cooling wastewaters from petroleum refineries. Such wastes include, but are not limited to, all sludges and floats generated in: induced air flotation (IAF) units, tanks and impoundments, and all sludges generated in DAF units. Sludges generated in stormwater units that do not receive dry weather flow, sludges generated from non-contact once-through cooling waters segregated for treatment from other process or oily cooling waters, sludges and floats generated in aggressive biological treatment units as defined in §261.31(b)(2) (including sludges and floats generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and F037, K048, and K051 wastes are not included in this listing.	11/2/90

Section 261.3(a)(2)(iv)(C) exempts K050 from the definition of hazardous waste when mixed with wastewater discharged under either section 402 or 307(b) of the Clean Water Act.

Section 261.4(a)(7) exempts spent sulfuric acid used to produce virgin sulfuric acid, unless it is accumulated speculatively as defined in §261.1(c). Spent sulfuric acid is one of the listing residuals of concern.

1.3 OTHER EPA REGULATORY PROGRAMS IMPACTING THE PETROLEUM REFINING INDUSTRY

Each of EPA's major program offices has long-standing regulatory controls tailored to the petroleum refining industry. Some of the more significant programs with some relevance to OSW's listing determinations include:

- The Clean Air Act's Benzene NESHAPs, designed to control benzene releases from process and waste management units.
- The Clean Air Act's National Ambient Air Quality Standards (NAAQS),
 which prescribe limits for SOx, CO, particulates, NOx, VOCs, and ozone.

- The Clean Air Act's NESHAPS for Petroleum Refineries (40 <u>CFR</u> Part 63 Subpart CC. August 18, 1995, 60 <u>FR</u> 43244, designed to control hazardous air pollutants (HAPs).
- Fuel specification rules established under the Clean Air Act which set the acceptable composition of gasoline and diesel fuel.
- The Clean Water Act sets specific technology-based limits and water qualitybased standards for discharges to surface waters and POTWs.
- The Toxicity Characteristic, particularly for benzene, in combination with the F037/F038 sludge listings, has had a significant impact on the industry's wastewater treatment operations, forcing closure of many impoundments and redesign of tank-based treatment systems.
- The LDR Program, including the ongoing Phase III and IV development work.

2.0 INDUSTRY DESCRIPTION

2.1 PETROLEUM REFINING INDUSTRY PROFILE

In 1992, the U.S. petroleum refining industry consisted of 185 refineries owned by 91 corporations. Figure 2-1 illustrates the distribution of refineries across the country. Refineries can be classified in terms of size and complexity of operations. Forty-four percent of the refineries process less than 50,000 barrels per day of crude, while the 20 largest companies account for 56 percent of the nation's total refining capacity.

The simplest refineries use distillation to separate gasoline or lube oil fractions from crude, leaving the further refining of their residuum to other refineries or for use in asphalt. Approximately 18 percent of the U.S.'s refineries are these simple topping, asphalt, or lube oil refineries. More sophisticated refineries will have thermal and/or catalytic cracking capabilities, allowing them to extract a greater fraction of gasoline blending stocks from their crude. The largest refineries are often integrated with chemical plants, and utilize the full range of catalytic cracking, hydroprocessing, alkylation and thermal processes to optimize their crude utilization. Section 3.0 describes the major unit operations typically found in refining operations.

The refining industry has undergone significant restructuring over the past 15 years. While the total national refining capacity dropped 17 percent since 1980 to 15 million barrels per day, the number of refineries dropped 45 percent from 311 in 1980 to approximately 171 active in 1992. Refinery utilization rates over the 1980 to 1992 period rose from 75 percent to 90 percent. (API, 1993). Very few new refineries have been constructed in the past decade; the industry instead tends to focus on expansions of existing plants.

The facilities closed tended to be smaller, inefficient refineries. Larger existing facilities with capacities over 100,000 bbl/day have increased production to off-set the facility closings.

The data presented above indicates that the petroleum refining industry has been going through a consolidation, which has resulted in a large decrease in the number of refineries in the United States, but only a slight decrease in production. It is expected that this trend will continue, with refineries continuing to close, but expansions occurring at others, keeping the total refinery capacity in line with demand for refinery products.

In addition to restructuring, the industry is adding and changing production operations. Although atmospheric and vacuum distillation, catalytic cracking, and their associated treating and reforming operations will remain the primary refinery operations, new production operations continue to be added. These include coking and desulfurization processes.

Many of these process changes are being implemented as a result of two factors: (1) today's crudes tend to be heavier and contain higher levels of sulfur and metals, requiring

process modifications, and (2) a series of important pollution control regulations have been implemented, including new gasoline reformulation rules designed to reduce the amount of volatile components in gasoline, and new regulations requiring low-sulfur diesel fuels. These heavier crudes and new rules are causing refineries to make process modifications to their catalytic cracker units, as well as installing additional sulfur removal hydrotreaters and unit processes to manufacture additives.

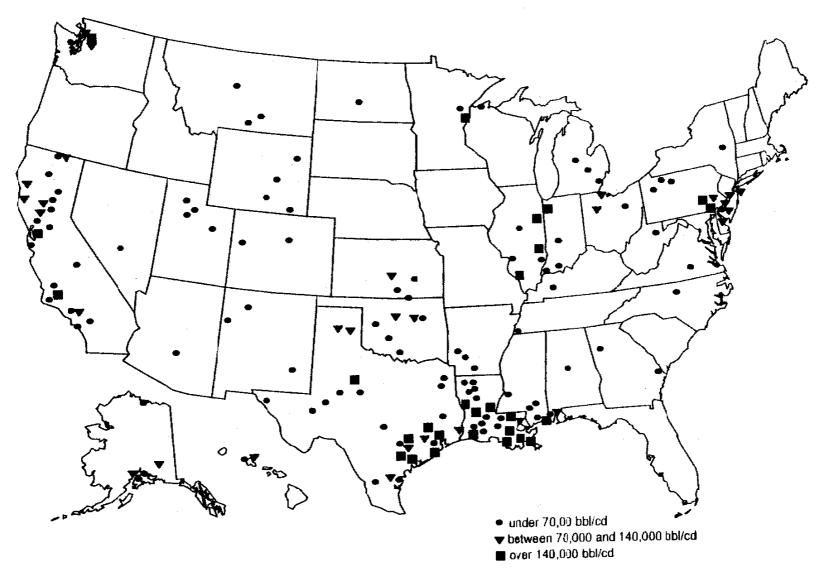


Figure 2.1. Geographical Distribution of U.S. Refineries

2.2 INDUSTRY STUDY

OSW's current listing determination for the petroleum refining industry has been underway since 1992 and can be characterized in terms of two major avenues for information collection: field work and survey evaluation. As part of the Agency's field work, engineering site visits, familiarization sampling, and record sampling were conducted. The survey effort included the development, distribution, and assessment of an extensive industry-wide RCRA §3007 survey. Each of these elements is described further below, reflecting the relative order in which these activities were conducted over the past three years.

2.2.1 Engineering Site Visits

EPA's field work activities were initiated with a series of engineering site visits. The primary purpose of these visits was to gather information about the 29 consent decree residuals and to identify appropriate sampling locations. After considering logistical and budgetary constraints, the Agency determined that it would conduct engineering site visits at 20 refineries prior to record sampling.

The Agency defined a site selection procedure that was used in selecting the 20 site visits from the population of 185 domestic refineries in the continental U.S.. The objectives of the selection procedure were:

- to ensure that the characterization data obtained from residuals at the 20 selected facilities could be used to make valid, meaningful statements about those residuals industry-wide.
- to give the Agency first-hand exposure to both large and small refineries.
- to be fair to all domestic refineries.

The Agency chose to select facilities randomly rather than purposefully. Although a randomly selected group of refineries may not offer as many sampling opportunities as a hand-picked group, the Agency favored random selection because it did not require subjective input, and also because it lends itself to statistical analysis, which is useful in making general statements about the population of residuals.

The Agency broke the industry into two strata based on atmospheric distillation capacity and made random selections from each stratum independently. The high-capacity stratum contains the top 30% of refineries, which together account for 70% of the refining industry's capacity. The stratification enables the Agency to weigh the selection toward the larger facilities on the basis that they produce larger volumes of residuals, and that they offer a larger number of residual streams per site visit. The Agency chose to select 12 of the 20 site visits, 60%, from the high-capacity stratum. The smaller facilities had a lower chance of

being selected, but not as low as they would have if the likelihood of selection was based strictly on size. The selected facilities are presented in Table 2.1¹.

An engineering site visit report was developed for each of the trips; these are available in the CBI and non-CBI dockets, as appropriate. For the later site visits conducted in 1994 and 1995, the engineering site visit reports were combined with the analytical data reports prepared for each facility. The site visit reports included the following elements:

- Purpose of the site visit
- Refinery summary, including general information gathered during the site visit, as
 well as data gleaned from telephone conversations and reviews of EPA files, the
 refinery's process flow diagram, and expected residual availability
- A discussion of the processes used at the refinery generating the residuals of concern
- Source reduction and recycling techniques employed by the refinery
- A description of onsite residual management facilities
- A chronology of the site visit.

¹ Upon initial contact with several of the randomly selected refineries, it was determined that they were inappropriate candidates for site visits because they had stopped operation and were not generating any residuals of interest to the Agency. Replacement facilities were then selected randomly from the same stratum.

The list of refineries slated for field investigations was expanded in June, 1994 to allow the Agency to fill out certain categories of samples that proved to be difficult to find in the field. The final list presented in Table 2.1 represents those refineries at which site visits actually occurred.

Table 2.1. Engineering Site Visit Facilities							
Refinery	Location	Initial Site Visit Date					
Amoco Oil	Texas City, Texas	March 29, 1993					
Arco	Ferndale, Washington	June 9, 1993					
Ashland	Canton, Ohio	May 24, 1993					
Ashland	Catlettsburg, Kentucky	March 22, 1993					
BP Oil	Belle Chasse, Louisiana	May 3, 1993					
BP Oil	Toledo, Ohio	May 26, 1993					
Chevron (purchased by Clark) 1	Port Arthur, Texas	August 31, 1994					
Chevron ¹	Salt Lake City, Utah	February 21, 1995					
Conoco 1	Commerce City, Colorado	To be determined					
Exxon	Billings, Montana	June 9, 1993					
Koch	St. Paul, Minnesota	May 19, 1993					
Little America	Evansville, Wyoming	June 8, 1993					
Marathon	Garyville, Louisiana	April 22, 1993					
Murphy	Superior, Wisconsin	May 17, 1993					
Pennzoil	Shreveport, Louisiana	May 5, 1993					
Phibro Energy ¹	Houston, Texas	April 20, 1995					
Rock Island (purchased by Marathon)	Indianapolis, Indiana	April 26, 1993					
Shell	Deer Park, Texas	March 31, 1993					
Shell	Norco, Louisiana	April 20, 1993					
Shell	Wood River, Illinois	May 28, 1993					
Star Enterprise 1	Convent, Louisiana	August 30, 1994					
Star Enterprise 1	Port Arthur, Texas	September 21, 1994					
Sun	Philadelphia, Pennsylvania	May 12, 1993					
Техасо	Anacortes, Washington	June 10, 1993					
Total	Ardmore, Oklahoma	June 23, 1993					
Young	Douglasville, Georgia June 21, 1993						

¹ Refinery selected to augment record sample availability.

2.2.2 RCRA §3007 Questionnaire

EPA developed an extensive questionnaire under the authority of §3007 of RCRA for distribution to the petroleum refining industry. A blank copy of the survey instrument is provided in Appendix A. The questionnaire was organized into the following areas:

- Corporate and facility information
- Crude oil and product information
- Facility process flow diagram
- Process units: general information
- Process units: flow diagrams and process descriptions
- Residual generation and management
- Residual and contaminated soil and debris characterization
- Residual management units: unit-specific characterization
- Unit-specific media characterization
- General facility characterization (focusing on exposure pathway characterization)
- Source reduction efforts
- Certification

The survey was distributed in August 1993 to all refineries identified as active in 1992 in the DOE Petroleum Supply Annual. Of the 185 surveys distributed, completed responses were obtained for 172 refineries. An additional 13 refineries notified EPA that they had stopped operations at some point in or after 1992 and thus were unable to complete the survey due to no staffing or inaccessible or unavailable data.

The completed surveys were reviewed by SAIC chemical engineers for completeness and then entered into a relational data base known as the 1992 Petroleum Refining Data Base (PRDB). The entries were subjected to a series of automated quality assurance programs to identify inappropriate entries and missing data links. An exhaustive engineering review of each facility's response was then conducted, resulting in follow-up letters to most of the industry seeking clarifications, corrections, and additional data where needed. The responses to the followup letters were entered into the database. A wide variety of additional quality assurance checks were run on the data, with added emphasis on the listing residuals, to ensure that the residuals of concern were characterized as completely and accurately as possible. Follow-up telephone interviews were conducted as necessary to address remaining data issues. After extensive review, the Agency believes that the data are reliable and represent the industry's current residual generation and management practices.

Table 2.2 describes the survey results for each of the listing residuals of concern, sorted by total volume generated in metric tons (MT).

Table 2.2. Listing Residuals Volume Statistics

Listing Residual Description	# of Reported Residuals	Total Volume (MT)
Catalyst from H2SO4 Alkylation	56	1,760,071
Spent Caustics from Liquid Treating	631	917,656
Off-Spec Product and Fines from Thermal Proces	s 90	194,262
FCC Catalyst	179	124,061
FCC Fines	105	67,816
CSO Sediments	42	24,010
Crude Oil Tank Sediments	99	22,017
Catalyst from Hydrorefining	73	18,634
HF Alkylation Sludge	33	11,288
Sulfur Complex Sludge (other than Stretford)	268	8,520
Catalyst from Hydrotreating	184	5,640
Catalyst from Claus Unit	93	3,819
Unleaded Gasoline Tank Sediments	125	3,583
Catalyst from Reforming	104	3,613
Sulfuric Acid Alkylation Sludge	13	608
Tail Gas Treating Catalyst (SCOT®-like)	23	361

2.2.3 Familiarization Sampling

The early phases of the analytical phase of this listing determination consisted of the development of a Quality Assurance Project Plan (QAPjP) for sampling and analysis, followed by the collection and analysis of five "familiarization" samples. The purpose of collecting these samples was to assess the effectiveness of the methods identified in the QAPjP for the analysis of the actual residuals of concern. Due to the high hydrocarbon content of many of the RCs, there was concern at the outset of the project that analytical interferences would prevent the contracted laboratory from achieving adequate quantitation limits; familiarization analysis allowed the laboratories to experiment with the analytical methods and waste matrices and optimize operating procedures.

In addition, the first version of the QAPjP identified a list of target analytes that was derived from previous Agency efforts to characterize refinery residuals. These included the Delisting Program's list of analytes of concern for refinery residuals, the "Skinner List", an evaluation of compounds detected in the sampling and analysis program for listing refinery residuals in the 1980s, and the judgement of EPA and SAIC chemists who evaluated the process chemistry of the residuals of concern. During familiarization sample analysis, particular attention was paid to the tentatively identified compounds to determine whether they should be added to the target analyte list.

Samples of five listing residuals were collected for familiarization analysis: crude oil tank sediments, hydrotreating catalyst, sulfur complex sludge, H₂SO₄ alkylation catalyst, and spent caustic. One study residual, acid soluble oil, was analyzed under this program. The results of the familiarization effort essentially confirmed the techniques identified in the QAPjP and indicated that the laboratories generally would be able to achieve adequate quantitation of the target analytes. The familiarization and final QAPjPs are provided in docket to this proposed rulemaking.

2.2.4 Record Sampling

Upon completion of the familiarization sampling and analysis effort, the Agency initiated record sampling and analysis of the listing and study residuals. Given budgetary constraints, the Agency set a goal of collecting 4-6 samples of each of the listing residuals, and 2-4 samples of the study residuals for a total of 134 samples². Table 2.3 shows the 103 samples that were actually collected. The numbers in the darkened boxes refer to Table 2.4 which lists each of the sample numbers, sample dates, facility names, and other information describing the residual samples.

The sampling team maintained monthly phone contact with the targeted refineries to maintain an optimized sampling schedule. Despite careful coordination with the refineries and best efforts to identify and collect all available samples, there were several categories for which the targeted minimum number of samples could not be collected:

- Three samples of unleaded gasoline tank sediments were collected. This residual is available only for a brief period during tank turnarounds, which may occur only every 10 years. In several cases, refineries informed EPA of planned tank turnarounds only to find no sediments upon opening the tanks for inspection. See Section 3.1.2.
- Three samples of hydrorefining catalyst were collected. As with the unleaded gasoline tank sediments, this residual is only generated on a periodic basis (e.g., every 3-5 years). Heroic efforts to locate additional samples were not expended because of the expected similarity between this residual and hydrotreating catalyst, for which 6 samples were successfully collected. As illustrated above in Table 2.2, the PRDB indicates that there were over twice the number of hydrotreater turnarounds (and catalyst generation events) as there were hydrorefiners.
- One sample of sulfuric acid alkylation sludge was collected. As is discussed further in Section 3.5.3, the Agency believes that this residual was

² The Agency determined that one listing residual, catalyst from sulfuric acid alkylation, would not be sampled due to the existing regulatory exemption for sulfuric acid destined for reclamation, and that one study residual, catalyst from HF alkylation, would not be sampled because the Agency believed it had been classified as a residual of concern inappropriately based on erroneous old data.

inappropriately misclassified as a listing residual due to the evaluation of inaccurate old data. This residual is not readily available, and was extremely difficult to find.

Each of the samples collected was analyzed for the total and TCLP concentrations of the target analytes identified in the QAPjP. In addition, certain residuals were tested for different characteristics based on the Agency's understanding of the residuals developed during the engineering site visits. Each sample was also analyzed for the ten most abundant nontarget volatile and the 20 most abundant nontarget semi-volatile organics in each sample. These tentatively identified compounds (TICs) were not subjected to QA/QC evaluation (e.g., MS/MSD analyses) and thus were considered tentative. The TIC results are available in the analytical data reports in the public docket to the proposed rule.

2.2.5 Split Samples Analyzed by API

The American Petroleum Institute (API) accompanied the EPA contractor (SAIC) on virtually all sampling trips and collected split samples of many of the record samples. API's analytical results for a number of the samples were made available to EPA for comparison purposes. In general, the Agency found that the API and EPA split sample analyses had very good agreement. Appendix B presents the Agency's comparison of the split sample results.

Table 2.3. Residuals Collected for Record Analysis

Exhibit 2. Impact of Potential Fall Sampling Opportunities on the Petroleum Refining Listing Determinations and Industry Study Sampling Effort

Sept. 21, 1995

		Recor	d Sam	ples					
Listing Residuals									
	i	2	3	- 4	5	6			
Crude oil tank sludge	3.3	.657 .	7.3	53	89	91	Ì		
Unleaded gasoline tank sludge	3.4	42	65						
CSO sludge	14	49	72	88					
FCC catalyst and fines	i	12	13	26	27	28	ĺ		
Catalyst from hydrotreating	6	11	รร	83	. 9.1	169	ı		
Catalyst from hydrorefining	21	***	85			}	١		
Catalyst from reforming	3	22	37	2,0	79	75	ĺ		
Sulfuric acid alkylation sludge	10.						1		
HF alkylation sludge	[1)	.1-	51	74	96]		
Sulfur complex sludge	10	25	29	80	7()		1		
Catalyst from sulfur complex	٠,	1.5	23	24	32	54	ı		
Off-spec product & fines/thermal process	30	45	59	63	81	84	İ		
Spent caustic	lo	17	32	62	04	95	ı		
On the Desiration	•								
Study Residuals		•	•						
Davidsel ell tools also des	1	2 92	3	4	extra				
Residual oil tank sludge	- 11		L.,	1447					
Desalting sludge		50	90	102					
Hydrocracking catalyst	1	13	87						
Catalyst from isomerization/extraction	311	18	7.1	97					
Treating clay from isomerization/extraction	68	17%	<u> </u>		_				
Catalyst from polymerization	3.5		663						
Treating clay, alkylation (HF and H2SO4).	20	^{**} 0.	No	1)1)					
ASO	18	3.8	· .	93					
Off-spec sulfur		8	} {}	[OO					
Spent amine solution	61	58	82	78					
Process sludge from residual upgrading									
Off-spec product, residual upgrading									
Treating clay from lube oil	(1)								

Notes:

Treating clay from clay filtering

Sulfuric Acid Alkylation catalyst is not presented in this figure. One familiarization sample of sulfuric acid catalyst was captured and analyzed. HF catalyst is constant boiling mixture (CBM) and is not shown in this figure. ASO is polymer.

31 57 101

Table 2.4. Descriptions of Sampass Collected for Record Analysis

Petroleum Refining Listing Determinations and Industry Study

21-Sep-95

Exhibit 2. List of Samples Captured to Date

Record Samples

		Sample	Sample		
Count	Residual Name	Number	Date	Notes	Refinery
ı	FCC catalyst and fines	R2-FC-01	30-Sep-93	ESP Fines.	Shell, Wood River, Illinois
2	Off-spec sulfur	R2-SP-01	30-Sep-93	Taken from low spots on the unit.	Shell, Wood River, Illinois
3	Catalyst from reforming	R2-CR-01	01-Oct-93	Platinum catalyst.	Shell, Wood River, Illinois
4	Catalyst from hydrocracking	R2-CC-02	04-Oct-93	2nd stage, Ni/W.	Shell, Wood River, Illinois
5	Desalting sludge	R1-DS-01	26-Oct-93	Removed from vessel.	Marathen, Indianapolis
6	Catalyst from hydrotreating	R1-TC-01	26-Oct-93	Naphtha reformer pretreat, CcMo.	Marathen, Indianapolis
7	Treating clay	R1-CF-01	27-Oct-93	Kerosene.	Marathen, Indianapolis
8	Off-spec sulfur	R1-SP-01	27-Oct-93	From product tank.	Marathon, Indianapolis
9	Catalyst from sulfur complex	R1-SC-01	27-Oct-93	Al2O3.	Marathon, Indianapolis
10	Sulfur complex sludge	R1-ME-01	27-Oct-93	MEA reclaimer bottoms.	Marathon, Indianapolis
11	Process sludge from residual upgrading	RI-RU-01	27-Oct-93	ROSE butane surge tank sludge.	Marathon, Indianapolis
12	FCC catalyst and fines	R4-FC-01	16-Nov-93	Equilibrium cat. from hopper.	Little America, Evansville, Wy
13	FCC catalyst and fines	R4-FC-02	16-Nov-93	ESP fines, truck trailer comp.	Little America, Evansville, Wy
14	CSO sludge	R4-S0-01	16-Nov-93	Tank sludge from pad.	Little America, Evansville, Wy
15	Catalyst from sulfur complex	R4-SC-01	16-Nov-93	Claus unit alumina, super sack comp.	Little America, Evansville, Wy
16	Spent caustic	R3-LT-01	18-Nov-93	Tank samp. Cresylic, concentrated.	Exxon, Billings, Montana
17	Spent caustic	R3-LT-02	18-Nov-93	Tank samp. Sulfidic, concentrated.	Exxon, Billings, Montana
18	ASO	R3-AS-01	18-Nov-93	Non-neutralized, separator drum sample	Exxon, Billings, Montana
19	HF alkylation sludge	R3-HS-01	18-Nov-93	Not dewstered. Dredge from pit.	Exxon, Billings, Montana
20	Treating clay from alkylation	R3-CA-01	18-Nov-93	HF. Propane treater. Drum composite.	Exxon, Billings, Montana
21	Catalyst from hydrorefining	R5-TC-01	07-Feb-94	Heavy Gas Oil, CoMo	Marathon, Garyville, LA
22	Catalyst from reforming	R5-CR-01	07-Feb-94	CCR fines, Pt	Marathon, Garyville, LA
23	Catalyst from sulfur complex	R5-SC-01	07-Feb-94	Claus	Marathon, Garyville, LA
24	Catalyst from sulfur complex	R5-SC-02	07-Feb-94	Tail gas, CoMo	Marathon, Garyville, LA
25	Sulfur complex sludge	R5-ME-02,03	07-Feb-94	Refinery MDEA filter cartridge	Marathon, Garyville, LA
26	FCC catalyst and fines	R5-FC-02	07-Feb-94	Wet Scrubber Fines	Marathon, Garyville, LA
27	FCC catalyst and fines	R6-FC-01	09-Feb-94	Equil. from unit	Shell, Norco, LA
28	FCC catalyst and fines	R6-FC-02	09-Feb-94	Wet scrubber fines	Shell, Norco, LA
29	Sulfur complex sludge	R6-ME-01	09-Feb-94	Refinery DEA filter cartridge	Shell, Norco, LA
30	Off-spec product & fines from thermal process	R6-TP-01	09-Feb-94	Coke fines.	Shell, Nerco, LA
31	Treating clay	R6-CF-01	09-Feb-94	Kerosene	Shell, Norco, LA

Table 2.4. Descriptions of Samples Collected for Record Analysis (continued)

32	Spent caustic	R6-LT-01	09-Feb-94	Naph. Comb. Gas oil & Kero	Shell, Norco, LA
33	Crude oil tank sludge	R6B-CS-01	15-Mar-94	Mix of centrifuge and uncentrifuged	Shell, Norco, LA
34	Unleaded gasoline tank sludge	R6B-US-01	March 31, 94	Water washed solids, collected by refiner	Shell, Norco, LA
35	Catalyst from polymerization	R6B-PC-01	March 15, 94	Dimersol filter	Shell, Noreo, LA
3 6	Catalyst from hydrorefining	R7B-RC-01	March 14, 94	Diesel hydrorefiner	BP, Belle Chase, LA
37	Catalyst from referming	R7B-CR-01	March 14, 94	Platinum	BP, Belle Chase, LA
38	ASO	R5B-AS-01	March 16, 94	Acid regen settler bottoms, not neutralize	Marathon, Garyville, LA
39	Catalyst from isomerization	R5B-1C-01	March 16, 94	Butamer, platinum	Marathon, Garyville, LA
40	Off-spec sulfur	R7B-SP-01	March 14, 94	From cleaned out tank	BP, Belle Chase, LA
41	Residual oil tank sludge	R8A-RS-01	April 30, 94	CSO and Resid.	Amoco, Texas City
42	Unleaded gasoline tank sludge	R8A-US-01	April 14, 1994	Collected by refinery	Amoco, Texas City
43	Catalysi from hydrocracking	R8A-CC-01	March 30, 94	Hydroproc., 1st stage cracker, CoMo	Amoco, Texas City
44	Catalyst from hydrotreating	R8A-TC-01	March 30, 94	NiMo, landfilled	Amoco, Texas City
45	Off-spec product & fines from thermal processes	R8A-TP-01	March 30, 94	Fines, F&K processed	Amoco, Texas City
46	H2SO4 alkylation sludge	R8B-SS-01	April 30, 94	From Frog pond, not dewatered	Amoco, Texas City
47	HF alkylation sludge	R8B-HS-01	April 30, 94	Not dewatered, dredged	Amoco, Texas City
48	Catalyst from isomerization	R8B-IC-01	April 30, 94	Butamer, Pt	Amoco, Texas City
49	CSO sludge	R9-SO-01,02	May 17, 94	Filters (and blank)	Murphy, Superior, WI
50	Desalting sludge	R9-D8-01	May 17, 94		Murphy, Superior, WI
51	HF alkylation sludge	R9-HS-01	May 17, 94		Murphy, Superior, WI
52	Catalyst from sulfur complex	R7B-SC-01	March 14, 94	SCOT catalyst	BP, Belle Chase, LA
53	Crude cil tank sludge	R10-CS-01	August 26, 94		Ashland, Catletsburg, KY
54	Catalyst from sulfur complex	R11-SC-01	May 10, 94	SCOT, CoMo	ARCO, Ferndale, WA
55	Catalyst from hydrotreating	R11-TC-01	May 10, 94	NiMo, naphtha treater	ARCO, Ferndale, WA
56	Catalyst from reforming	R11-CR-01	May 10, 94	Pt/Rh	ARCO, Ferndale, WA
57	Treating clay	R11-CF-01	May 10, 94	Reformer sulfur trap	ARCO, Ferndale, WA
58	Spent amine	R11-SA-01	May 10, 94	DEA	ARCO, Ferndale, WA
59	Off-spec product & fines from thermal processes	R11-TP-01	May 10, 94	Coke fines	ARCO, Ferndale, WA
60	Treating clay from lube oil	R13-CL-01	April 30, 94	Clay dust	Shell, Deer Park, TX
61	Spent amine	R13-SA-01	April 30, 94	DEA	Shell, Deer Park, TX
62	Spent caustic	R13-LT-01	April 30, 94	Sulfidic	Shell, Deer Park, TX
63	Off-spee product & fines from thermal processes	R12-TP-01	May 12, 94	Coke fines, from trap	Texaco, Anacortes, WA
64	Spent caustic	R12-LT-01	May 12, 94	Cresylic	Texaco, Anacortes, WA
65	Unleaded gasoline tank sludge	R16-US-01	Aug 3, 94		Koch
66	Catalyst from polymerization	R16-PC-01,02	Aug 3, 94	2 catalysts from Dimersol and H2PO4	Koch
67	Crude oil tank sludge	R8C-CS-01	Jul, 94	collected by refinery from tank bottom	Amoco, Texas City
68	Treating clay from extraction	R8D-CI-01	November 15, 94	collected by refinery	Amoco, Texas City
69	Catalyst from hydrotreating	R18-TC-01	October 20, 94	naptha	Ashland, Canton, OH

Sulfur complex sludge R18-ME-01 October 14, 94 MEA sludge, collected by refinery Ashland, Canton, C R18-IC-01 October 20, 94 Penex Ashland, Canton, C R18-IC-01 August 26, 94 Mixed CSO/resid Marathon, Indiana R18-CS-01 August 25, 94 Fifter cake sludge Little America R15-HS-01 Aug 2, 94 Dredged from pit Total, Ardmore, O R15-CR-01 Aug 2, 94 Butane Total, Ardmore R15-CA-01 Aug 2, 94 R15-AS-01 Aug 2, 94 Butane Total, Ardmore R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 Neut., skimmed from pit R15-CR-01 Aug 2, 94 Neu	
Crude oil tank sludge R4B-CS-01 August 25, 94 Filter cake sludge Little America HF alkytation sludge R15-HS-01 Aug 2, 94 Dredged from pit Total, Ardmore, O Catalyst from reforming R15-CR-01 Aug 2, 94 CCR fines Total, Ardmore Treating clay from alkylation R15-CA-01 Aug 2, 94 Butane Total, Ardmore ASO R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O R15-SA-01 Aug 2, 94 MDEA	H
HF alkytation sludge R15-HS-01 Aug 2, 94 Dredged from pit Total, Ardmore, O Catalyst from reforming R15-CR-01 Aug 2, 94 CCR fines Total, Ardmore Treating clay from alkylation R15-CA-01 Aug 2, 94 Butane Total, Ardmore ASO R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O	olis
75 Catalyst from reforming R15-CR-01 Aug 2, 94 CCR fines Total, Ardmore 76 Treating clay from alkylation R15-CA-01 Aug 2, 94 Butane Total, Ardmore 77 ASO R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O 78 Spent amine R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O	
76 Treating clay from alkylation R15-CA-01 Aug 2, 94 Butane Total, Ardmore 77 ASO R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O 78 Spent amine R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O	ζ
77 ASO R15-AS-01 Aug 2, 94 Neut., skimmed from pit Total, Ardmore, O 78 Spent amine R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O	
78 Spent amine R15-SA-01 Aug 2, 94 MDEA Total, Ardmore, O	
	K
79 Catalyst from reforming R14_CR_01 June 7 94 Cyclic Pt reformer RD Tolado OU	K
77 Camiya non releasing tra-cites and 1,74 Cyclic i telefine Dr., 101000, On	
80 Sulfur complex sludge R14-ME-01 June 7, 94 DEA diatomaceous earth BP, Toledo, OH	
81 Off-spec product & fines from thermal processes R14-TP-01 June 7, 94 Delayed coking fines BP, Toledo, OH	
82 Spent amine R14-SA-01 June 7, 94 DEA from sump BP, Toledo, OH	
83 Catalyst from hydrotreating R3B-TC-01 July 12, 94 Naptha treater Exxon, Billings, M	Ŧ
84 Off-spec product & fines from thermal processes R3B-TP-01 July 12, 94 Fluid coker chunky coke Exxon, Billings, M	ľ
85 Catalyst from hydrorefining R21-RC-01 August 31, 94 Chevron, Port Arth	ur, TX
86 Treating clay from alkylation R21-CA-01 August 31, 94 Chevron, Port Artl	ur, TX
87 Catalyst from hydrocracking R20-CC-01 August 30, 94 H-Oil unit, moving bed Star, Convent, LA	
88 CSO sludge R20-S0-01 August 30, 94 Star, Convent, LA	
89 Crude oil tank sludge R19-CS-01 September, 94 BP, Belle Chase, I	A
90 Desaiting sludge R11B-DS-01 September, 94 to be collected by refinery ARCO, Ferndale,	ŀΑ
91 Crude oil tank sludge R22-C8-01 September 21, 94 Star, Port Arthur,	Ϋ́X
92 Residual oil tank studge R22-RS-01 September 21, 94 Star, Port Arthur,	X
93 ASO R7C-AS-01 October 12, 94 BP, Belle Chase, I	Á
94 Catalyst from hydrotreating R22-TC-01 September 21, 94 Star, Port Arthur,	Ϋ́
95 Spent caustic R22B-LT-01 October 11, 94 caustic from H2SO4 alky, sulfidic Star, Port Arthur,	X
96 HF alkylation sludge R7C-HS-01 October 12, 94 Filter press BP, Belle Chase, I	A
97 Catalyst from isomerization R23B-Cl-01 April 19, 1995 Pt catalyst Chevron, Salt Lake	City
98 Treating clay from isomerization R23B-IC-01 April 19, 1995 Mole sieve, butamer feed treater Chevron, Salt Lake	City
99 Treating clay from alkylation R23-CA-01 January 17, 95 propane treater Chevron, Sait Lake	City
100 Off-spec sulfur R23-SP-01 January 17, 95 Chevron, Salt Lake	-
101 Treating clay from clay filtering R23-CF-01 January 17, 95 diesel washed Chevron, Salt Lake	City
102 Desalting sludge R24-DS-01 April 20, 1995 Sludge from Lakos separator Phibro, Houston, T	X

Table 2.4. Descriptions of Samples Collected for Record Analysis (continued)

Familiarization Samples

Fl	Spent Caustic	A-SC-01	08-May-93	Comingled.	Marathon, Garyville
F2	Catalyst from hydrotreating	A-HC-01	10-May-93	Cobalt molybdenum.	Marathon, Garyville
F3	Sulfur complex sludge	C-SS-01	23-Jun-93	MEA Reclaimer sludge.	Amoco, Texas City
F4	ASO	C-AS-01	23-Jun-93	Neutralized.	Amoco, Texas City
F5	Crude oil tank sludge	B-TS-01	15-May-93	Filter cake.	Sun, Philadelphia
F6	Sulfuric Acid Catalyst	B-SA-01	15-May-93	Spent from third unit.	Sun, Philadelphia

3.0 PROCESS AND WASTE DESCRIPTIONS

Refineries in the United States vary in size and complexity and are generally geared to a particular crude slate and, to a certain degree, reflect the demand for specific products in the general vicinity of the refinery. Figure 3.1 depicts a hypothetical refinery that employs the major, classic unit operations used in the refinery industry. These unit operations are described briefly below, and in more detail in the remainder of this section. Each subsection is devoted to a major unit operation that generates one or more of the listing residuals of concern and provides information related to the process, a description of the residual and how and why it is generated, management practices used by the industry for each residual, the results of the Agency's characterization of each residual, and summary information regarding source reduction opportunities and achievements.

Storage Facilities: Large storage capacities are needed for feed and products. Sediments can accumulate in these storage units. The consent decree identifies sediments (sludges) from the storage of crude oil, clarified slurry oil, and unleaded gasoline for consideration as listed wastes. Residual oil storage tank sediments were identified as a study residual.

Crude Desalting: Clay, salt, and other suspended solids must be removed from the crude prior to distillation to prevent corrosion and deposits. These materials are removed by water washing and electrostatic separation. Desalting sludge is a study residual.

Distillation: After being desalted, the crude is subjected to atmospheric distillation, separating the crude by boiling point into light ends, naphtha, middle distillate (light and heavy gas oil), and a bottoms fraction. The bottoms fraction is frequently subjected to further distillation under vacuum to increase gas oil yield. No residuals from distillation are under investigation.

Catalytic Cracking: Catalytic cracking converts heavy distillate to compounds with lower boiling points (e.g., naphthas), which are fractionated. Cracking is typically conducted in a fluidized bed reactor with a regenerator to continuously reactivate the catalyst. Cracking catalysts are typically zeolites. The flue gas from the regenerator typically passes through dry or wet fines removal equipment prior to being released to the atmosphere. Catalyst and fines, as well as sediments from storage of clarified slurry oil (the bottoms fraction from catalytic cracking), are listing residuals of concern.

Hydroprocessing: Hydroprocessing includes (1) hydrotreating and hydrorefining (or hydrodesulfurization), which improve the quality of various products (e.g., by removing sulfur, nitrogen, oxygen, metals, and waxes and by converting olefins to saturated compounds); and (2) hydrocracking, which cracks heavy materials, creating lower-boiling, more valuable products. Hydrotreating is typically less severe than hydrorefining and is applied to lighter cuts. Hydrocracking is a more severe operation than hydrorefining, using higher temperature and longer contact time, resulting in significant reduction in feed molecular size. Hydroprocessing catalysts are typically some combination of nickel,

molybdenum, and cobalt. Typical applications of hydroprocessing include treating distillate to produce low-sulfur diesel fuel, treating naphtha reformer feed to remove catalyst poisons, and treating catalytic cracking unit feed to reduce catalyst deactivation. Hydrotreating and hydrorefining catalysts are listing residuals, while hydrocracking catalyst is a study residual.

Thermal Processes: Thermal cracking uses the application of heat to reduce high-boiling compounds to lower-boiling products. Delayed (batch) or fluid (continuous) coking is essentially high-severity thermal cracking and is used on very heavy residuum (e.g., vacuum bottoms) to obtain lower-boiling cracked products. (Residuum feeds are not amenable to catalytic processes because of fouling and deactivation.) Products are olefinic and include gas, naphtha, gas oils, and coke. Visbreaking is also thermal cracking; its purpose is to decrease the viscosity of heavy fuel oil so that it can be atomized and burned at lower temperatures than would otherwise be necessary. Other processes conducting thermal cracking also would be designated as thermal processes. Off-spec product and fines is a listing category from these processes.

Catalytic Reforming: Straight run naphtha is upgraded via reforming to improve octane for use as motor gasoline. Reforming reactions consist of (1) dehydrogenation of cycloparaffins to form aromatics and (2) cyclization and dehydrogenation of straight chain aliphatics to form aromatics. Feeds are hydrotreated to prevent catalyst poisoning. Operations may be semiregenerative, cyclic, or, less frequently, fully-regenerative, continuous, or moving bed catalyst systems. Precious metal catalysts are used in this process. Spent reforming catalyst is a listing residual.

Polymerization: Polymerization units convert olefins (e.g., propylene) into higher octane polymers. Two principal types of polymerization units include fixed-bed reactors, which typically use solid-supported phosphoric acid as the catalyst, and Dimersol[®] units, which typically use liquid organometallic compounds as the catalyst. Spent polymerization catalyst is a study residual.

Alkylation: Olefins of 3 to 5 carbon atoms (e.g., from catalytic cracking and coking) react with isobutane (e.g., from catalytic cracking) to give high octane products. Sulfuric (H₂SO₄) or hydrofluoric (HF) acid act as catalysts. Spent sulfuric acid, sulfuric acid alkylation sludges, and HF sludges are listing residuals, while spent HF acid, acid soluble oil and treating clays are study residuals.

Isomerization: Isomerization converts straight chain paraffins in gasoline stocks into higher octane isomers. Isomer and normal paraffins are separated; normal paraffins are then catalytically isomerized. Precious metal catalysts are used in this process. Spent catalysts and treating clays are study residuals from this process.

Extraction: Extraction is a separation process using differences in solubility to separate, or extract, a specific group of compounds. A common application of extraction is the separation of benzene from reformate. Treating clay is a study residual from this process.

Lube Oil Processing: Vacuum distillates are treated and refined to produce a variety of lubricants. Wax, aromatics, and asphalts are removed by unit operations such as solvent extraction and hydroprocessing; clay may also be used. Various additives are used to meet product specifications for thermal stability, oxidation resistances, viscosity, pour point, etc. Treating clay is a study residual from this process.

Residual Upgrading: Vacuum tower distillation bottoms and other residuum feeds can be upgraded to higher value products such as higher grade asphalt or feed to catalytic cracking processes. Residual upgrading includes processes where asphalt components are separated from gas oil components by the use of a solvent. It also includes processes where the asphalt value of the residuum is upgraded (e.g., by oxidation) prior to sale. Off-spec product and fines, as well as process sludges, are study residuals from this category.

Blending and Treating: Various petroleum components and additives are blended to different product (e.g., gasoline) specifications. Clay and caustic may be used to remove sulfur, improve color, and improve other product qualities. Spent caustic is a listing residual, while treating clay is a study residual.

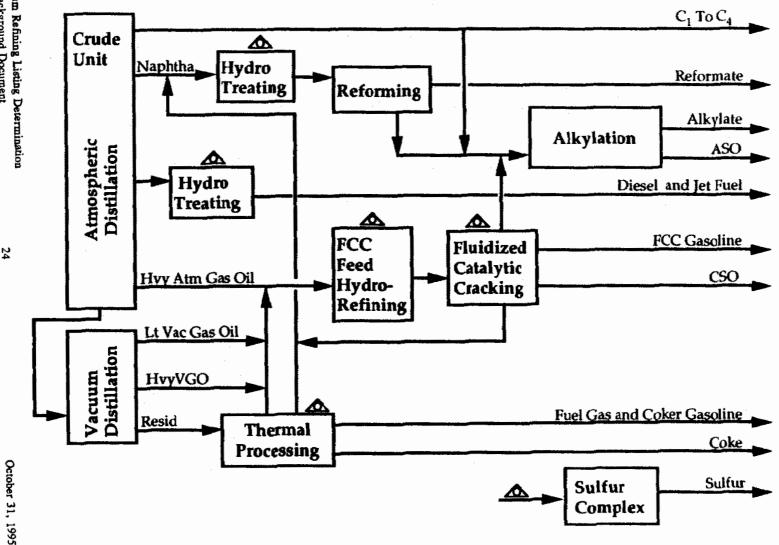
Sulfur Recovery: Some types of crude typically contain high levels of sulfur, which must be removed at various points of the refining process. Sulfur compounds are converted to H₂S and are removed by amine scrubbing. The H₂S typically is converted to pure sulfur in a Claus plant. Off-gases from the Claus plant typically are subject to tail gas treating in a SCOT® unit for additional sulfur recovery. Process sludges and spent catalysts are listing residuals; off-spec product and off-spec treating solutions are study residuals.

Light Ends (Vapor) Recovery: Valuable light ends from various processes are recovered and separated. Fractionation can produce light olefins and isobutane for alkylation, n-butane for gasoline, and propane for liquid petroleum gas (LPG). No residuals from this process are under investigation for either the listing determination or the study.

Typical Petroleum Refining Process Flow Diagram

Figure 3.1.

Simplified Process Flow Diagram



3.1 TANK STORAGE RESIDUALS

Almost every refinery stores its feed and products in tanks onsite. Occasionally (every 10 to 20 years), tanks require sediment removal due to maintenance, inspection, or sediment buildup. These tank bottoms are removed by techniques ranging from manual shoveling to robotics and filtration.

3.1.1 Crude Oil Storage Tank - Residual 1

In 1992, U.S. refineries reported approximately 1,200 crude oil storage tanks with an average tank volume of about 163,000 barrels. DOE's <u>Petroleum Supply Annual 1992</u> reported refineries processed just under 5 billion barrels of crude oil or approximately 13.4 million barrels per day.

3.1.1.1 Description

Crude oil tank sediment consists of heavy hydrocarbons, basic sediment and water (BS&W), and entrapped oil that settles to the bottom of the tank. It can be manually removed directly from the tank after drainage of the crude or, commonly, removed using a variety of oil recovery techniques. The recovered oil is returned generally to crude storage while the remaining solids are collected and discarded as waste.

Once a tank is taken out of service, many refineries use in situ and ex situ oil recovery techniques. Common in situ oil recovery techniques include hot distillate washing, and steam stripping. This allows entrapped oil to float to the top of the sediment layer and be recovered prior to removal of the sediment from the tank. Ex situ recovery methods are usually performed by a contractor at the tank site and include filtration, centrifuging, and settling. Separated oil is recycled back to the process or sent to the slop oil tanks, and the water phase is sent to the wastewater treatment plant (WWTP). The solids are managed in a variety of ways, including disposal at Subtitle C and D landfills and in land treatment units.

Many refineries reduce tank bottom buildup with intank mixers. Mixers keep the sediments or solids continuously in suspension so that they travel with the crude oil to the refining process. The solids are then carried to the desalter where the de-emulsifiers remove them from the crude. This increases the volume of desalting sludge generated.

68% of crude tanks have mixers

In 1992, thirty-three percent of the volume of crude tank bottom sediment was reported to be managed as hazardous. A majority of the residuals were reported as exhibiting the toxicity characteristic for benzene (D018) and/or were ignitable.

3.1.1.2 Generation and Management

The refineries reported generating 22,017 MT of crude oil tank bottom sediment in 1992. Residuals were assigned to be "crude oil tank sediment" if they were assigned a residual identification code of "crude oil tank sediment," corresponding to residual code 01-A in Section VII.2 of the questionnaire. Process wastewaters, decantates, and recovered oils (e.g., from deoiling or dewatering operations) were eliminated from the analysis. These correspond to residual codes 09, 10, and 13 (new) in the questionnaire. Quality assurance was conducted by ensuring that all crude oil tank sediments previously identified in the questionnaire (i.e., in Section V.D) were assigned in Section VII.2. Table 3.1.1 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment modeling. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.1.1 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite land treatment (used for 12.2% of the sediments)
- Offsite land treatment (used for 0.9% of the sediments)
- Offsite Subtitle D landfilling (10.6% of sediments)

An onsite monofill scenario was rejected because of the intermittent (every 10 years) generation frequency which is not typical of waste that tends to be monofilled.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.1.2. The Agency did not model interim storage of crude oil tank sediment because of the infrequency of residual generation and the relatively short time-frame during which the residual is stored onsite prior to final management. EPA observed a number of tank turnarounds during engineering site visits and sampling trips. The refineries generally allotted four to six weeks for a tank turnaround. The first few weeks of the turnaround are used for draining down the tank, in situ oil recovery, and preparing the tank for entry. Tank sediments then are removed from the tank (via vacuuming, shovel), sometimes de-oiled (via centrifuge or filter press), and placed in dumpsters. The Agency believes that refineries are motivated to move these dumpsters off of the tank facilities (and to final management) as quickly as possible due to financial constraints (e.g., cost of container rental, contractor costs) and space constraints. As a result, the sediments are probably stored onsite for less than a month prior to final management. Because this time period is so limited, the Agency assumed that the potential for contaminant release and exposure at levels of concern was insignificant in comparison with the long-term risks associated with landfilling and land treatment. Therefore, on-site storage was not modeled in the Agency's risk assessment.

Table 3.1.1. Generation Statistics for Crude Oil Tank Sediment					
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)
Discharge to onsite WWTP; discharge to surface water under NPDES	5	0	2,118	529.5	2,115 ²
Disposal offsite in Subtitle D landfill	19	6	2,337.6	123	347
Disposal onsite Subtitle C landfill	1	0	117	117	117
Disposal offsite in Subtitle C landfill	28	2	3,785.6	135.2	400
Discharge to onsite WWT; effluent discharged to evaporation pond	1	0	132	132	132
Offsite incineration3	2	0	116	58	82.1
Offsite land treatment	6	1	199	33	100
Onsite land treatment	14	3	2,685.6	192	537.5
Transfer for use as fuel	4	1	578.6	144.6	529
Transfer for use as ingredient in products placed on the land	. 2	0	43.6	22	32
Transfer with refinery product	1	0	150	150	150
Transfer to other offsite entity	1	0	63 <i>.</i> 5	63.5	63.5
Recovery onsite ¹	14	15	9,676	666.5	1,000
Other reuse/cover for onsite landfill	1	0	14.6	14.6	14.6
Total Crude Oil Tank Sediment	99	28	22,017	222	400

Other recovery onsite includes recovery in catalytic cracker, coker, or distillation units or in asphalt production.

Sediment removed from tank and trucked to WWTP where it is bled into the treatment system to any

Sediment removed from tank and trucked to WWTP where it is bled into the treatment system to avoid overloading the biological treatment system.

³ Hazardous waste incinerators.

Table 3.1.2. Selection of Risk Assessment Modeling Scenario: Crude Oil Tank Sediment		
Management	Basis for Consideration in Risk Assessment	
Discharge to onsite WWTP; discharge to surface water under NPDES	Not modeled. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be captured by existing hazardous waste listings and further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.	
Disposal offsite in Subtitle D landfill	Modeled	
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control	
Disposal onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control	
Discharge to onsite WWT; effluent discharged to evaporation pond	Not modeled, waste is discharged to wastewater treatment (see above). Minimal volume, reported only by one facility.	
Recovery onsite ¹	Proposed excluded management practice	
Offsite land treatment	Modeled	
Onsite land treatment	Modeled	
Transfer for use as fuel	Not modeled. Already regulated if characteristic. Minimal volume reported.	
Transfer for use as ingredient in products placed on the land	Not modeled. Already regulated if characteristic. Minimal volume and already modeled land application in land treatment scenario.	
Transfer with refinery product	Not modeled. Proposed excluded management practice.	
Offsite incineration	Not modeled, hazardous waste incineration - no incremental risk to control	
Recovery onsite via distillation	Not modeled, exempt management practice	
Transfer to other offsite entity	Not modeled, exempt management practice. Minimal volume.	
Other reuse/cover for onsite landfill	Not modeled. Minimal volume, unlikely to present risk. Land application and landfill scenarios modeled.	

¹ Other recovery onsite includes recovery in catalytic cracker, coker, or distillation units.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.1.3 provides a summary of the data for the targeted management practices used in the risk assessments for the crude oil tank sediments. Appendix C summarizes §3007 data regarding runon/runoff controls for these units.

Many refineries conduct de-oiling of crude oil tank sediment, both before and after removal from the storage tank. The Agency evaluated whether de-oiling has any impact on the risks associated with the disposed sediment. The Agency hypothesized that de-oiling might reduce toxicant concentrations for certain toxicant fractions (e.g., volatiles), although others could be concentrated (e.g., metals). Samples were collected of sediments with and without de-oiling after removal from the storage tanks (described further in Section 3.1.1.3). Total oil and grease content was analyzed for each sample (see also Section 3.1.1.3).

The following conclusions were reached regarding the effects of de-oiling on the risks associated with this residual:

- (1) De-oiling reduces volume, which, if all other factors were held constant, would tend to reduce the risk modeled. The average de-oiled crude oil tank sediment volume is 120 MT, while the average oily sediment volume is 350 MT.
- (2) De-oiled sediments are predominantly sent for onsite land treatment (37%), disposed offsite in a Subtitle D landfill (24%), or disposed offsite in Subtitle C landfill (17%). Oily sediments are more liked to be recycled to the process (57%), disposed of in an offsite Subtitle C landfill (17%), and discharged to onsite WWTP (14%).
- (3) The oil and grease levels remaining in the sediment after de-oiling are highly variable among refineries (4.87 to 41.1 percent), even when similar techniques are used. One de-oiled record sample had oil and grease concentrations at the same level as another oily record sample.
- (4) The Agency observed a wide range of effectiveness and combinations of *in situ* and *ex situ* techniques. At certain refineries (perhaps many), centrifuging and other types of mechanical de-oiling techniques are only used on those sediments which fail the "paint filter test" which is used as a surrogate for recoverable oil. As a result, the upper layers of tank sediment are subjected to *ex situ* de-oiling, while the lower layers are not de-oiled. Tank operating conditions may also affect sediment content, such as the use of in-tank mixers and ambient temperature at the time of sediment removal.

After considering all of these factors, the Agency determined that differentiating between oily and de-oiled sediments was inappropriate.

Table 3.1.3. Management Practices Targeted for Risk Assessment							
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Offsite Subtitle D Landfill ³	12	19	6	2,337.6		29.75	632
Offsite Land Treatment Unit ³	4	6	1	199		44	100
Onsite Land	9	14	3	2,685.6		38	1,839
Treatment Unit ^{1,3}				Characteristic	3		
	Surface A	rea (acres)			3.5	14.5	32
	Depth of l	Incorporation	(in)		6	9.5	13.5
	Amount A	pplied (1992	MT) ²		0.3	272	12,000
,	Methods of Incorporation: Disking (16) Subsurface Injection (1) Springtooth Harrow (1)						
	# of Land	fills: 18			**************************************		
			Aq	uifer Informat	noi		
	Depth to	Aquifer (ft)	·		12.5	17.5	150
	Distance t	o Private We	ell (ft)		2,000	9,000	26,400
	Population	Using Prive	ite Well		0	1.5	300
	Distance t	o Public We	Ц (ft)		2,000	18,480	52,800
	Population	Using Publ	io Well		250	250	250
	# of Aqui	fers: 14					
	Source: Public Private Unreported 9 7 Uppermost 1 3 Lowermost 4 4 Combination — — Classification of Uppermost Aquifer: Current or potential source of drinking water (4) Not considered a potential source of drinking water (9)						

¹ The number of onsite land treatment units characterized in Table 3.1.3 is greater than indicated in Table 3.1.1 which focuses only on volumes generated in 1992. Table 3.1.3 incorporates data from all onsite land treatment units receiving crude oil tank sediment in any year reported in the §3007 survey.

² Volumes represent the average volume of all wastes applied to the land treatment units accepting the crude tank sediment and not just the tank sediment alone.

³ The mean and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream from one refinery may be disposed of in one management unit causing the 90th percentile number actually to be the sum of 2 or 3 waste volumes).

Table 3.1.4. Crude Oil Tank Sediment Physical Properties						
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %	
pH	116	182	6	7 .4	8.6	
Reactive CN, ppm	66	232	0.1	34.5	120	
Reactive S, ppm	82	216	0.1	232.4	500	
Flash Point, °C	101	196	29.4	70	100	
Oil and Grease, vol %	106	192	5	34.3	80	
Total Organic Carbon, vol %	39	259	0	23	65	
Viscosity, lb/ft-sec	5	289	0.02	12.5	60	
Specific Gravity	76	222	0.84	1.52	1.86	
BTU Content, BTU/lb	54	244	100	7,281	14,499	
Aqueous Liquid, %	154	144	0	19.2	50	
Organic Liquid, %	157	141	0	31.8	80	
Solid, %	190	108	9.5	54.5	100	
Particle >60 mm, %	21	277	0	19.2	100	
Particle 1-60 mm, %	24	274	0	18.5	50	
Particle 100 μm-1 mm, %	24	274	0	52.25	98	
Particle 10-100 μm, %	24	274	0	17.2	45	
Particle <10 μm, %	17	281	0	1	7	
Mean Particle Diameter, microns	13	284	10	1,683	1000	

3.1.1.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.1.4 summarizes the physical properties of the crude oil tank sediment as reported in Section VII.A of the §3007 survey.
- Six record samples of actual sediments were collected and analyzed by EPA. These sediments represent the various types of oil recovery typically used by the industry and are summarized in Table 3.1.5.

Table 3.1.6 provides a summary of the characterization data collected under this sampling effort. All the record samples collected are believed to be representative of the crude oil tank sediment as generated. The samples collected of the composite of oily and deoiled sediment are representative of industry de-oiling practices. It is common practice for the refinery to recover oil from the top layers of sediment where there is a high percentage of free oil, but as the top layers are removed the bottom layers will contain less free oil and more asphaltenes. At most refineries, the paint filter test is performed on the sediment throughout the tank cleaning/sediment de-oiling process. Once the sediment passes the paint filter test, the sediment de-oiling (centrifuging/filtering) process is stopped and the remainder of the sediment is removed directly from the tank without de-oiling. Therefore, refineries may perform oil recovery only at the beginning of tank cleaning operations.

As illustrated in Table 3.1.6, two samples exhibited the characteristic for benzene. Oil and grease content ranged between 4 and 41 percent. Only constituents detected in at least one sample are shown in this table.

Tab	Table 3.1.5. Crude Oil Tank Sediment Record Sampling Locations								
Sample No.	Facility	Description: Oil Recovery	Oil & Grease Content						
R6B-CS-01	Shell, Norco, LA	Composite of non-centrifuged and centrifuged sediment.	24.2%						
R10-CS-01	Ashland, Catlettsburg, KY	Liquidized and recycled to the catalytic cracker. Sample collected prior to liquification.	41.1%						
R8C-CS-01	AMOCO, Texas City, TX	Collected directly from the tank by refinery personnel.	24.7%						
R4B-CS-01	Little America, Casper, WY	Composite of centrifuged and non-centrifuged sediment.	15.4%						
R19-CS-01	Pennzoil, Shreveport, LA	Filtered.	14.4%						
R22-CS-01	Star Enterprises, Port Arthur, TX	De-oiled using a shaker.	4.87%						

Table 3.1.6. Crude Oil Tank Sediment Characterization

OSSIGN OF STREET	- Melhod 8260A j	µg/kç							•	90% Confidence Interval	
CAS No.	R68-CS-91			R10-C5-01	R19-CS-01		Average Conc	Meximum Cono	Std Dev	Jopes Umit	Comme
107028	< 31,250	< \$2,500	< 2,500	24,000	< 600		6.420	24,000	P.882	15,195	1
71432	69,000	220,000	8,200	52,000	660	< 2,500	58,727	220,600	83,960	109,319	•
104518	32,000	50,000	37,000	49,000 J	1.000	6,900	29,317	50,000	20,908	41,916	
135958	21,000	36,000	13,000	25,000			18,528	36,000	13,470	24,645	
100414	79,000	260,000	38,000	120,000	430	25,000	67,072	260,000	84,680	144,123	
98828	32,000	70,000	15,000	41,000		4,100	27,420	70,000	25,908	43,032	
99876	19,000	31,000	12,000	30,000		£ 500	18,342	31,000	12,629	23,951	
78933	6.250			29,000		< 2,500	6,892				
103651	40,000	110,000						29,000	10,722	15,352	
108883	200,000	400,000				11,000	27,558	110,000	43,064	53,507	
				140,000		< 2,500	128,973	400,000	155,411	222,520	
95636	150,000	330,000		160,000	4,100	64,000	120,517	330,000	116.392	196,651	
108678	120,000	160,000	73,000	100,000	1,700	7,100	76,967	160,000	\$2,091	114,923	
95476	150,000	320,000	67,000	170,000 J		< 2,500	118,405	320,000	121,801	191,700	
08383 / 106423	320,000	830,000	160,000	390,990	1,400	18,000	289,000	630,000	307,205	475,014	
91203	84,000	210,000	65,000	68,000	2,400	5,100	70,750	210,000	75,620	116,437	
	ranics Mathods								ı	90% Confidence Interval	
CAS No.	R6B-CS-01	R&C-CS-01	R48-C5-01	R10-CS-01	R19-CS-01	R22~C\$-01	* .	Maximum Conc	Std Dev	Upper Limit	Cemar
		270		120	140		140	270	88	193	
71432	1,700	1,600	130	56 0 J	32	< 50	679	1,700	777	1,147	
100414	240	370	J 80	180	c 50	210	190	370	114	259	
108863	1,900	1,600	230	930 -	c 50	< 50	793	1,900	814	1,254	
95636	260	160	190	150 J	24	100	147	260	08	196	
108678	100	J 54	< 50	45	3	< 50	58	100	21	71	
75092	< 50		1 [< 50	170		70	170	40	100	
95476	580	480	170	310	i	< 50	273	583	223	408	
08383 / 106423	1,500					120	682	1,500	603		
91203	150	1,300 J 97	300	670 ·				300	99	1,045 175	
91203	150	J 97							99	175 90% Confidence	
91203 Semivokille Orga	150	J 97 2708 µg/kg	300) 61 <u>1</u> 1	38	< 50	118	300	99	175 90% Confidence Interval	
91203 iemiyokille Orga CAS No	150 Inics — Method 82 R68-CS-01	J 97 2708 µg/kg R6C-CS-01	300 . R4B-CS-01) 61 J	38 R19-CS-01	< 50 R22-C\$-01	118 Average Conc	300	99 Std Dev	175 90% Confidence Interval Upper Limit	Comm
91203 emivolalije Orga CAS No 83329	150 inica – Method 82 R68-CS-01 < 10,313	J 97 2708 µg/kg R6C~CS-01 13,000	848-CS-01) 61 J R10~CS-01 < 49,500 €	R19-CS-01	< 50 R22-C\$-01 < 413	116 Average Conc 30,621	300 Maximum Cone 99,000	99 Std Dev 37,505	175 90% Cordidence Interval Upper Limit 53,221	Comm
91203 emivolalije Orga CAS No 83329 120127	150 unice - Method 82 R68-CS-01 < 10,913 < 10,913	J 97 270B µg/kg R6C→CS→01 12,000 < 4,125	R4B-CS-01 99,000 90,000	R10~CS-0: < 49,500 < 49,500 <	R19-CS-01 c 11,500	< 50 R22-C\$-01 < 413 < 413	118 Average Conc 30,621 27,642	300 Maximum Cone 99,000 90,000	99 Std Dev 37,505 35,276	175 90% Corrildence Interval Upper Limit 53,221 48,898	
91203 emivolalile Orga CAS No 83229 120127 56553	150 Linica — Welhod 82 R6B-CS-01 < 10,313 < 10,313	J 97 2708 μg/kg R6C~CS~01 13,000 < 4,125 < 4,125	R4B-CS-01 99,000 90,000 31,000	R10~CS-0: < 49,500 < 49,500 < 49,500	R19-CS-01 < 11,500 < 11,500 < 11,500	R22-C\$-01 413 413 413	116 Average Conc 30,621 27,642 11,470	300 Maximum Cono 99,000 90,000 31,000	99 Std Dev 37,505 35,276 11,821	175 90% Corrildance Interval Upper Limit 53,221 48,898 19,574	1
91203 emivolalile Orga CAS No 83329 120127 56553 NA	150 Inice - Method 82 R68-CS-01 < 10,313 < 10,313 < 10,313	J 97 2708 µg/kg R6C-CS-01 13,000 4,125 4,125 J 5,900	R4B-CS-01 99,000 97,000 31,000 29,000	R10~CS-0: < 49,500; < 49,500; < 49,500; < 49,500;	R19-CS-01 c 11,500 c 11,500 c 11,500 c 11,500	R22-C\$-01 < 413 < 413 < 413 < 413	116 Average Conc 30,621 27,642 11,470 11,425	300 Maximum Conc 99,000 90,000 31,000 29,000	99 Std Dev 37,505 35,275 11,821 10,748	175 90% Corrildence Interval Upper Limit 53,221 48,898	
91203 emivoisille Orga CAS No 83329 120127 66553 NA 191242	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313	J 97 2708 µg/kg R8C~CS-01 13,000 < 4,125 < 4,125 J 5,900	R4B-CS-01 99,000 90,000 31,000 29,000	R10~CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500	R19-CS-01 (11,500 (11,500 (11,500 (11,500 (11,500 (11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 419 < 419	118 Average Conc 30,621 27,642 11,470 11,425 10,845	300 Maximum Core 99,000 90,000 31,000 29,000 18,000	99 Std Dev 37,505 35,276 11,821	175 90% Corrildance Interval Upper Limit 53,221 48,898 19,574	
91203 emivolalile Orga CAS No 83929 120127 56553 NA 191242 80328	150 Inica – Method 82 FIGB-CS-01 10,313 10,313 10,313 10,313 117,000	J 97 2708 µg/kg R6C − CS − 01 13,000 < 4,125 < 4,125 J 5,900 18,000 J 6,600	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 29,000	R10~CS-O: < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500;	R19-CS-01 c 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413	116 Average Conc 30,621 27,642 11,470 11,425	300 Maximum Conc 99,000 90,000 31,000 29,000	99 Std Dev 37,505 35,275 11,821 10,748	175 90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792	1
91203 emivolalie Orga CAS No 83326 120127 60553 NA 191242 80328 86748	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313	J 67 2708 µg/kg R6C~CS~01 13,000 < 4,125 J 5,900 18,000 J 6,600 < 8,250	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 140,000	R10~CS-O: < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500;	R19-CS-01 C 11,500 C 11,500 C 11,500 C 11,500 C 11,500 C 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413	118 Average Conc 30,621 27,642 11,470 11,425 10,845	300 Maximum Core 99,000 90,000 31,000 29,000 18,000	99 Std Dev 37,505 35,275 11,821 10,748 0,533	175 90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792 15,324	1
91203 emivolalile Orga CAS No 83929 120127 56553 NA 191242 80328	150 Inica – Method 82 FIGB-CS-01 10,313 10,313 10,313 10,313 117,000	J 97 2708 µg/kg R6C − CS − 01 13,000 < 4,125 < 4,125 J 5,900 18,000 J 6,600	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 140,000	R10~CS-0: < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 9,000; < 9,000;	R19—CS—01 c 11,500 c 20,500	R22-C\$-01 R22-C\$-01 < 413 < 413 < 419 < 419 < 413 < 825	118 Average Conc 30,621 27,642 11,470 11,425 10,845 12,303	300 Maximum Conc 99,000 90,000 31,000 29,000 18,000 26,000	99 Std Dev 37,505 35,275 11,821 10,748, 6,533 9,801	175 90% Confidence Interval Upper Limit 53,221 48,896 19,574 18,792 15,324 19,022	1 1
91203 emivolalie Orga CAS No 83326 120127 60553 NA 191242 80328 86748	150 Inica – Method 82 FR68 – CS – 01 < 10,313 < 10,313 < 10,313 < 10,313 J 17,000 < 20,625	J 67 2708 µg/kg R6C~CS~01 13,000 < 4,125 J 5,900 18,000 J 6,600 < 8,250	R4B-CS-01 99,000 96,000 31,000 29,000 14,000 20,000 42,000	F10-CS-01 49,500 49,500 49,500 49,500 49,500 99,000 49,500	R19-CS-01 4 11,500 5 11,500 6 11,500 6 11,500 6 11,500 6 11,500 7 11,500 7 11,500 7 11,500	R22-C\$-01 R22-C\$-01 413 413 413 413 413 413 413 4	Average Conc 30,621 27,642 11,470 11,425 10,845 12,303 48,700	300 Maximum Cono 99,000 90,000 31,000 29,000 18,000 140,000	99 Std Dev 37,505 35,275 11,821 10,746 6,533 9,801 50,051	90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792 15,324 19,022 83,017	1 1
91203 CAS No 8332a 120127 80553 NA 191242 80328 80748 218019	150 Inice - Method 82 R6B-CS-01 < 10.313 < 10.313 < 10.313 < 10.313 < 10.313 < 10.313 J 17,000 < 20,625 J 13,000	J 97 2708 µg/kg R8C - CS - 01 13,000 4,125 4,125 J 5,900 18,000 4,600 6,250 28,000	R4B-CS-01 99,000 90,000 31,000 14,000 140,000 42,000 4,125	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 99,000 < 49,500	R19-CS-01 4 11,500 5 11,500 6 11,500 6 11,500 6 11,500 6 11,500 7 11,500 7 11,500 7 11,500	R22-C\$-01 R22-C\$-01 413 413 413 413 413 413 413 4	Average Conc 30,021 27,642 11,475 10,845 12,903 48,700 19,183	300 Maximum Cons 99,000 90,000 31,000 29,000 18,000 140,000 12,000 12,000	99 Std Dev 37,505 35,275 11,821 10,748 6,533 9,801 50,951 18,328 4,763	90% Corrildance Interval Upper Limit 53,221, 48,598, 19,574, 15,792, 15,324, 19,022, 83,017, 30,377, 11,113	1 1 1
91203 emivolsille Crgs CAS NO 83329 120127 50553 NA 191242 60328 80748 218019 132649	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 20,625 J 13,000 < 10,313	J 97 2708 µg/kq R6C~CS~01 13,000 < 4,125 J 5,900 18,000 4 6,000 29,000 12,000 4,125	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 4,125 J 3,700	R10~CS-0: < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 19,000; < 19,000; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500; < 49,500;	R19-CS-01 11,500 11,500 11,500 11,500 11,500 11,500 23,500 11,500 11,500 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413	Average Conc 30,621 27,642 11,470 11,425 10,845 12,903 48,700 19,183 8,225 2,054	300 Maximum Conc 99,000 99,000 31,000 29,000 18,000 140,000 42,000 12,000 3,700	99 Std Dev 37,505 35,275 11,821 10,746 6,533 9,801 50,651 18,322 4,703 2,325	90% Confidence Interval Upper Limb 53,221 48,898 19,574 16,792 15,324 19,022 83,017 30,377 11,113 7,116	1 1 1
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91203 emivolalie Orga CAS No 83329 120127 50553 NA 191242 50328 80748 218019 132049 53703 91941 296440 86737	150 Inice - Method 82 R68-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313	J 67 2708 µg/kg R8C~CS~01 13,000 < 4,125 J 5,900 J 8,600 < 9,250 29,000 12,000 < 4,125 < 4,750 J 6,400 32,000	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 4,125 J 3,700 4,750 72,000 62,000	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 19,000 < 49,500 < 90,000 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500	R19-CS-01 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413	Average Conc 30,621 27,642 11,470 11,425 12,903 48,700 19,183 8,225 2,050 1,800 25,021 28,800	300 Maximum Conc 99,000 99,000 31,000 29,000 18,000 140,000 42,000 12,000 3,700 1,800 72,000 62,000	99 Std Dev 37,505 35,275 11,821 10,748 0,533 9,801 50,951 18,326 4,763 2,325 NA 28,837 21,144	90% Confidence Interval Upper Limb 53,221 48,898 19,574 16,792 15,324 19,022 83,017 30,377 11,113 7,116 NA 42,397 41,541	1 1 1 1,2
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91203 CAS No 8332a 120127 50553 NA 191242 50328 80748 218019 132049 53703 81941 206440 86737 193395 85018	150 Inice - Method 82 R6B-CS-01 < 10.313 < 10.313 < 10.313 < 10.313 < 10.313 J 17,000 < 20,625 J 13,000 < 10,313 < 10,313 < 10,313 < 10,313 < 7,000 < 10,313 37,000 < 10,313	J 97 2708 µg/kg R6C - CS - 01 13,000 4,125 4,125 J 5,900 18,000 28,000 12,000 4,125 4,125 4,125 5,900 12,000 12,000 30,000 J 3,000 J 3,000	R4B-CS-01 99,000 96,000 31,000 29,000 14,000 42,000 42,000 42,000 4,125 J 3,700 4,750 72,000 62,000 15,000 380,000	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500	R19-CS-01 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413	Average Conc 30,021 27,642 11,470 11,425 10,845 12,903 48,700 19,183 8,225 2,050 1,800 25,021 28,600 8,045 99,133	300 Maximum Conc 99,000 90,000 31,000 29,000 18,000 42,000 12,000 1,700 1,800 72,000 62,000 15,000 380,000	99 Std Dev 37,505 95,275 11,821 10,748 6,533 9,801 56,951 18,329 4,793 2,325 NA 28,837 21,144 6,107 140,666	90% Confidence Interval Upper Limit 53,221 48,898, 19,574 18,792 15,324 19,022 83,017 30,377 11,113 7,116 NA 42,397 41,541 12,231	1 1 1 1 1,2
91203 emivolalie Crgs CAS No 83329 120127 56553 NA 191242 50328 66748 218019 132049 53703 91941 296440 86737 193395 85018 129000	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 37,000 < 10,313 73,000 J 12,000	J 67 708 µg/kg R8C - CS - 01 13,000 < 4,125 J 5,900 18,000 4,125 29,000 12,000 < 4,750 J 6,400 32,000 76,000 120,000	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 < 4,125 J 3,700 < 4,750 72,000 62,000 15,000 72,000 72,000	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500	R19-CS-01 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413	Average Conc 30,621 27,642 11,470 11,425 12,903 48,700 19,183 8,225 2,050 1,800 25,021 28,800 8,045 99,133	300 Maximum Conc 99,000 99,000 31,000 29,000 18,000 140,000 42,000 12,000 3,700 1,800 72,000 62,000 15,000 380,000	99 Std Dev 37,505 35,275 11,821 10,748 6,533 9,801 50,951 18,329 4,703 2,325 NA 28,837 21,144 6,107 140,666 45,678	90% Confidence interval Upper Limb 53,221; 48,896 19,574; 18,792; 15,324; 19,022; 83,017; 30,977; 11,113; 7,116; NA, 42,397; 41,541; 12,231; 183,895; 71,941	1 1 1 1,2
91203 GAS No 8332a 120127 60553 NA 191242 90328 80748 218019 12264a 53703 91941 206440 85737 19395 85018 129000 90120	150 Inice - Method 82 R68-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 J 17,000 < 20,625 J 13,000 < 10,313 < 10,313 < 10,313 < 10,313 73,000 12,000 240,000	J 87 2708 µg/kg R6C~CS~01 13,000 4,125 4,125 J 5,900 18,000 4,250 28,000 12,000 4,125 4,750 J 6,400 32,000 120,000 120,000 210,000	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 4,125 J 3,700 4,750 72,000 15,000 380,000 1,300,000	R10~CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 19,000 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500	R19-CS-01 (11,500 (11,	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 <	Average Conc 30,621 27,642 11,475 10,845 12,303 48,700 19,183 8,225 2,053 1,800 25,021 28,800 8,045 99,133 44,235	300 Maximum Cone 99,000 99,000 31,000 29,000 18,000 140,000 12,000 1,000 1,000 1,000 15,000 3,700 15,000 380,000 120,000 1,000	99 Std Dev 37,505 35,275 11,821 10,746 6,533 9,801 16,226 4,763 2,925 NA 28,837 21,144 6,107 140,666 45,978 479,643	90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792 15,324 19,022 83,017 30,377 11,113 7,116 NA 42,397 41,541 12,231 183,895 71,941 644,437	1 1 1 1,2
91203 Gemivokalile Orgs CAS No 8332a 120127 80553 NA 191242 90328 80748 218019 132049 53703 191941 206440 80737 193395 85018 129000 90120 91576	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 37,600 J 12,000 J 12,000 240,000	J 97 2708 µg/kg R6C - CS - 01 13,000 4,125 4,125 5,900 18,000 28,000 12,000 4,125 4,750 J 6,400 32,000 120,000 120,000 120,000 450,000	R4B-CS-01 99,000 96,000 31,000 29,000 14,000 42,000 42,000 4,125 J 3,700 4,750 72,000 62,000 15,000 380,000 72,000 1,300,000 2,100,000	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 37,000 < 40,500 340,000 370,000 370,000	R19=CS=01 < 11,500 < 11,500	R22-C5-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 5000 < 413 < 1,3000 < 413 < 19,0000 < 419 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000	Average Conc 30,021 27,642 11,475 10,845 12,903 48,700 19,183 8,225 2,05a 1,800 25,021 28,600 8,045 99,133 44,235 365,417 536,683	300 Maximum Conc 99,000 90,000 31,000 29,000 140,000 42,000 12,000 1,800 72,000 62,000 15,000 380,000 1,20,000 2,100,000	99 Std Dev 37,505 35,275 11,821 10,748 0,533 9,801 10,29 4,793 2,325 NA 28,837 21,144 0,107 140,666 45,878 479,643 787,035	90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792 15,324 19,022 83,017 30,977 11,113 7,116 NA 42,397 41,541 12,231 183,895 71,941 644,437 1,013,130	1 1 1 1,2 1
91203 CAS No 83329 120127 50553 NA 191242 90328 80748 218019 132049 53703 91941 206440 66737 193395 85018 129000 90120 91576 3351324	150 Inice - Method 82 R6B-CS-01 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 <10,313 37,600 <10,313 73,000 J12,000 240,000 J 8,300	J 67 R*C~C\$~01 13,000 13,000 14,125 15,900 18,000 18,000 12,000 12,000 14,000 76,000 120,000 120,000 210,000 210,000 210,000 210,000 210,000 210,000 210,000 210,000	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 < 4,125 J 3,700 < 4,750 72,000 62,000 15,000 380,000 72,000 1,300,000 J 7,300	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000 < 90,000	R19-CS-01 11,500	R22-C\$-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 500 < 413 < 1,300 < 413 < 1,300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 300 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 41	Average Conc 30,621 27,642 11,470 11,425 12,903 48,700 19,183 8,225 2,050 1,800 25,021 28,800 8,045 9,133 44,235 365,417,538,883 9,356	300 Maximum Conc 99,000 90,000 31,000 29,000 18,000 140,000 42,000 12,000 3,700 1,800 72,000 62,000 15,000 380,000 120,000 2,100,000 21,000	99 Std Dev 37,505 35,275 11,821 10,748 6,533 9,801 50,951 18,326 4,763 2,325 NA 28,837 21,144 6,107 140,666 45,678 479,643 787,035 8,440	90% Confidence interval Upper Limb 53,221; 48,896; 19,574; 18,792; 15,324; 19,022; 83,017; 30,377; 11,113; 7,116; NA, 42,397; 41,541; 12,231; 183,895; 71,941; 544,437; 1,013,130; 16,289	1 1 1 1,2 1
91203 Gemivokalile Orgs CAS No 8332a 120127 80553 NA 191242 90328 80748 218019 132049 53703 191941 206440 80737 193395 85018 129000 90120 91576	150 Inice - Method 82 R6B-CS-01 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 10,313 < 37,600 J 12,000 J 12,000 240,000	J 97 From pg/kg From CS-01 13,000 13,000 18,000 18,000 12,000 12,000 14,125 4,125 4,125 4,750 4,125 10,400 120,000 120,000 120,000 120,000 120,000 120,000 120,000 120,000 120,000 450,000 210,000 4,125	R4B-CS-01 99,000 90,000 31,000 29,000 14,000 42,000 42,000 4,750 72,000 15,000 380,000 72,000 1,300,000 2,100,000 2,100,000 1,300,000 1,200,000	R10-CS-01 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 49,500 < 37,000 < 40,500 340,000 370,000 370,000	R19-CS-01 (11,500) (1	R22-C5-01 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 413 < 5000 < 413 < 1,3000 < 413 < 19,0000 < 419 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000 < 19,0000	Average Conc 30,021 27,642 11,475 10,845 12,903 48,700 19,183 8,225 2,05a 1,800 25,021 28,600 8,045 99,133 44,235 365,417 536,683	300 Maximum Conc 99,000 90,000 31,000 29,000 140,000 42,000 12,000 1,800 72,000 62,000 15,000 380,000 1,20,000 2,100,000	99 Std Dev 37,505 35,275 11,821 10,748 0,533 9,801 10,29 4,793 2,325 NA 28,837 21,144 0,107 140,666 45,878 479,643 787,035	90% Confidence Interval Upper Limit 53,221 48,898 19,574 18,792 15,324 19,022 83,017 30,977 11,113 7,116 NA 42,397 41,541 12,231 183,895 71,941 644,437 1,013,130	1 1 1 1,2 1

Acenaphthene
Arthracena
Benz(a) anthrecene
Banzoliuoranthene (total)
Banzo(g,h,l)perylene
Benzo(a)pyrene
Casbazole
Chaysens
Diberzoturan
Dibert(e,h)anthracene
3,3'-Dichloroberzidine
Fluoranthene
Fluorene
Indeno(1,2,3-cc)pyrene
Prenanthrene
Pyrene
1 - Methyinephihalene
2 - Methylnaphthalene
2-Methylchrysene
3/4Malhylphenol

Nephihalene

Acrolein Benzene n-Bulylbenzene sec-Butylbanzana Ethylbenzene isopropy/benzere p-leopropylioluine Methyl ethyl ketone n-Propylbanzara Totuene

Acetone Bertzene Ethylbenzene Toluene

1,2,4-Trimathylbergene 1,3,5-Trimelhylbergene o-Xylene m,p-Xylenes Naphthaiene

1,2,4-Trimethylbergene 1,3,5-Trimelhytherzene Mathylene chloride o-Xylena m,p-Kylene Naphihalene

CRUDE TANK BLUDGE

Acenaphihene Di-n-butylphthalate Caubazola 2.4-Dimethylphenol Dimethyl phthelde Fluorens 1-Methylnaphthelene 2-Methylnaphthelene 2-Methylpheno 3/4-Methylphenol Naphthalena Phenanthrene Phenol

Auminum Antimony Amenic Berturn Cadmium Calcium Chromlum Cobat Copper **FOR** Lead Magneskim Manganese Mescury Molybdenum Nickel Bodium Vanadium Zino

Barlum Calcium 1ron Manganese Zho

1											(10% Contidence	
TCLP 8		e Organice — Mi	dh	ods 1311 and 62	270B µg/L							interval	
CAS	S No.	R56-C5-0		R8C-C8-01	R48-C8-01	R10-C8-01	R18-CS-01	R22-CS-01	Average Conc	Maximum Conc	Std Dev	Upper Umit	Comments
1	83320	< 5	0 .	< 50	J 19	< 50	< 60	50	10	10	NA	NA.	1
	84742	< 5	٥į.	< 50	< 50	< 60	J 52 J	15	45	52	14	53	2
	86748	< 10	0	c 100	J 73	< 100	< 100 <	100	73	73	NA	NA NA	1
	105079	< 5	о.	< 50	J 39	< 60	< 50 <	50	39	30	NA	NA.	1
	131113	< 5	이	< 50	< 50	J 12	< 50	: 50	12	12	NA	NA.	1
1	86737	< 6	0		J 18	< 50	< 50	50	18	18	NA	NA	1
1	90120	J 3	3 J	27	640	1 39	< 100 J	13	142	640	240	290	
l	91578	J 3	6 J	50	890:	J 39	< 50 J	12	180	098	348	390	
1	95487	< 5	о.	< 50	J 31	< 60	< 50	¢ 50	31	31	NA	NA.	1
l N	MA I	< 5	ol٠	c 50	490	< 50	< 50 -	50	123	490	160	232	
1	91203	J 6	5	17	500	J 50		14	128	500	164	238	
	85018	< 5	ol.	< 50	J 27	< 50	< 50	50	27	27	NA.	ΝÅ	ı
	108952	< 5	ol.	< 60	160			50	68	160	45	95	
1			٠,		,,					,		,	
												90% Confidence	
Total M	otale M	elhods 6010, 70	60	7421, 7470, 747	71, and 7841 mg/l	kn						Interval	
	S No.	R68-C9-0		BIC-CS-01	R48-C9-01	R10-C8-01	R18-CS-01	R22-C3-01	Average Conc	Maximum Conc	Std Day	Upper Limit	Comments
	7420005	2,200	٠.	6,600.0	1,600.0	330.0	1,600.0	780.0	2.551.7	8.600.0	3.041.4	4,384.4	
	7440360	< 6.	-	< 6.0	< 12.0		< 8.0	15.0	8.5	15.0	4.0	10.6	
	7440382	6.	-1	8.3	32.0	5.7	:6.0	19.0	14.8	32.0	10.3	31.6	
	7440393	4,400		300.0	950.0	520.0	1,200.0	330.0	1,333,3	4,400.0	1,543.2	2,283.2	
	7440430	1,-10	_	1.2			< 0.5	2.0	1.1	2.0	0.6	1.5	
	7440702	10,000		14,000.0	11,000.0	2,300.0	9,900,0	25,000.0	12,033.3	25,000.0	7.430.3	16,514.3	
	7440473	49		310.0	51.0	9.7	150.0	100.0	113.6	310.0	108.0	177.C	
	7440484	16.	_	360.0			17.0	27.0	72.3	360.0	141.1	157.4	
	7440508	1 3 0.	-1	170.0	190.0	73.0	320.0	870.0	292.2	870.0	294.7	489.8	
	7439890	18,000		25,000.0	200,000.0	26,0000	120,000.0	300,000,0	114.833.3	300,000.0	115.0741	184.535.8	
	7439921	220		44.0	320.0	44.0	0.00	50.0	259.7	670.0	319.6	452.2	
	7439054	1,200		1,400.0			< 500.0	4,200.0	1,406.7	4,200.0	1,388.0	2,303.1	
	7439965	140		160.0	750.0	130.0	590.0	2,200.0	561.7	2,200.0	700.7	1,143.6	
	7439976	0		2.5	0.7	0.3	1.8	2.5	1.4	2.5	1.0	2.0	
	7430067	< 6	- 1	660.0	1		23.0	22.0	158.5	880.0	353.5	371.5	
	7440020	84	-1	380.0	61.0	15.0	£2.0	74.0	112.7	380.0	133.0	192.8	
	7440236	2,800	_	5,300.0			1,100.0	1,000.0	2116.7	6,300.0	2,195.6	3,439.8	
	7440622	10.	_	1,400.G		12.0	13.0		241.7	1,400.0	567.5	583.6	
	7440000	670		640.0		360.D	670.0	1,200.0	750.7	1,200.0	297.2	935.8	
	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		•		,	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		.,	, , , ,	.,,	207721		
1													
												90% Confidence	
TOPM	intela N	fethods (311.60	310	7000 7421 74	70,7471, and 764	fi med						interval	
	6 No.	R68-CS-0		R&C-C8-01		R10-CS-01	R19-CS-01	R22-C\$-01	Average Conc	Maximum Conc	Std Day	Upper Limb	Comments
	7440393			2.40			270		1.52	2.70	0.81	2.00	
	7440702			550.00	260.00		120,00	270.00	208.33	550.00	199.11	328.31	
	7439898	1.4		110.00		6.40	55.00	800.00	74.97	800.00	309.00	361.16	
	7439965	0.1		1.30	2.50	0.59	0.69	7.80	2.17	7.60	2.88	3.90	
	7440560	0.2		0.21			0.83			1	0.27	0.48	
'			· · ·	J.E.	, 2.57	3.19	-441	3.40	3.01	3.00,		3.40	

Comments:

- Detection limits greater than the highest detacted concentration are excluded from the calculations.
- 2 Upper Limit exceeds the maximum concentration

Notes:

- B. Analyse also detected in the associated method blank.
- J. Compound's concentration is estimated. Make spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection lints, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

3.1.1.4 Source Reduction

In situ oil recovery techniques can greatly reduce the total amount of crude oil tank sediment to be disposed as well as reduce volatile constituents such as benzene. As discussed above, recovery methods include distillate washing, nonpetroleum solvent washing, water wash with surfactant, and steam stripping. These operations allow entrapped oil to float to the top of the sediment layer and be recovered prior to removal from the tank. Separated oil is recycled back to the process or sent to the slop oil tanks, and the water phase is sent to the WWTP.

As reported in the §3007 survey, the average amount of oily sediment (not centrifuged/filtered/settled) generated is 350 MT while the average quantity for sediment that was centrifuged, filtered, or settled was 120 MT, a 66% volume reduction.

Another method to reduce tank bottom buildup in tanks is to install mixers. Mixers keep the sediments or solids continuously in suspension so that they travel with the crude oil to the refining process. The solids are then carried to the desalter where they result in an increase the volume of desalting sediment generated.

3.1.2 Unleaded Gasoline Storage - Residual 2

In 1992, 146 U.S. refineries reported approximately 1,400 unleaded gasoline storage tanks with an average capacity of 237,000 barrels, according to the §3007 survey. The survey requested that the refineries report only finished product tanks and not tanks that store intermediate products such as alkylate. Facilities that did not report unleaded gasoline storage include lube plants, asphalt plants, and facilities that do not perform finished gasoline blending onsite.

3.1.2.1 <u>Description</u>

Approximately every 10 years, gasoline storage tanks are taken out of service to inspect the tank's integrity. At that time, the product is drained from the tank and the tank is cleaned.

Unleaded gasoline tank sediment consists of tank scale and rust. A typical cleaning procedure is to wash the inside of the tank with water (to decrease occupational benzene levels), discharging the water to the sewer, and sweep or scrape the remaining solids for disposal. It is not uncommon for no solids to be generated.

As with crude oil storage tanks, mixers are also installed in unleaded gasoline tanks to reduce tank bottoms sediment accumulation. However, due to the nature of the gasoline production process, very few solids should be in the gasoline.

Once the tank sediment has been removed and any repairs have been made, some refineries paint the tank's interior with an epoxy to protect the tank and reduce rust and scale generation.

In 1992, 25 percent of the volume of unleaded gasoline sediment was reported to be hazardous. A majority of these residuals were reported as exhibiting the toxicity characteristic for benzene (D018) and/or the ignitability characteristic.

3.1.2.2 Generation and Management

The refineries reported generating 3,583 MT of unleaded gasoline tank bottom sediment in 1992. Residuals were assigned to be "unleaded gasoline tank sediment" if they were assigned a residual identification code of "unleaded gasoline tank sediment," corresponding to residual code 01-C in Section VII.2 of the questionnaire. Process wastewaters and decantates (e.g., from deoiling or dewatering operations) were eliminated from the analysis. These correspond to residual codes 09 and 10 in the questionnaire. Quality assurance was conducted by ensuring that all unleaded gasoline tank sediments previously identified in the questionnaire (i.e., in Section V.D) were assigned in Section VII.2. Table 3.1.7 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.1.7. Generation Statistics for Unleaded Gasoline Tank Sediment						
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)	
Discharge to onsite WWTP; ultimate discharge to surface water	16	9	2,091	130.7	120	
Disposal offsite in Subtitle D landfill	28	7	625	22.3	47.7	
Disposal onsite Subtitle D	3	0	8.4	2.8	6.6	
Disposal onsite and offsite in Subtitle C landfill	27	3	106	5.9	19	
Offsite incineration ¹	8	0	176. 7	22	60.7	
Other disposal onsite	1	0	18	18	18	
Recovery onsite	4	9	92.7	23	30	
Offsite land treatment	8	0	98.22	12.3	66	
Onsite land treatment	15	2	118	8	20,6	
Transfer for use as fuel	1	0	195	195	195	
Total unleaded gasoline sediment	111	30	3,583	32.3	66	

¹ Four facilities send wastes to 3 hazardous waste incinerators.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.1.8 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite land treatment (used for 3.1% of sediment)
- Offsite Subtitle D landfilling (16.5% of sediment)
- Onsite Subtitle D landfilling (0.2% of sediment)

An onsite monofill scenario was rejected because the intermittent (every 10 years) generation frequency and small quantities are not typical of wastes that tend to be monofilled.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.1.8.

Table 3.1.8. Selection of Risk Assessment Modeling Scenario: Unleaded Gasoline Tank Sediment					
Waste	Basis for Consideration in Risk Assessment				
Discharge to onsite WWTP; ultimate discharge to surface water	Not modeled. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be captured by existing hazardous waste listings and further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.				
Disposal offsite in Subtitle D landfill	Modeled				
Disposal onsite in Subtitle D landfill	Modeled				
Disposal onsite and offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control				
Offsite incineration	Not modeled, hazardous waste incinerators - no incremental risk to control				
Other disposal onsite	Not modeled, minimal volume				
Recovery onsite	Proposed excluded management practice				
Offsite land treatment	Modeled				
Onsite land treatment	Modeled				
Transfer for use as fuel	Not modeled, already regulated if characteristic, minimal volume reported.				

The Agency evaluated whether it was necessary to model short-term on-site storage of unleaded gasoline tank sediment prior to final management. Using the same logic described in the previous discussion of the selection of management practices to be modeled for crude oil tank sediment, EPA determined that the potential for contaminant release and exposure at levels of concern was insignificant in comparison with the long-term risks associated with landfilling and land treatment. Therefore, on-site storage was not modeled in the Agency's risk assessment.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.1.9 provides a summary of the data for the targeted management practices used in the risk assessment.

Table	Table 3.1.9. Management Practices Targeted for Risk Assessment									
	Unleaded Gasoline Tank Sediment									
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)			
Offsite Land Treatment ³	3	8	0	98.22		2.22	94			
Onsite Land	9	15	2	118		2	57			
Treatment Unit ^{1,3}			(c) (c)	Characterist	ics					
	Surface A	rea (acres)			2	14.5	32.3			
	Depth of	Incorporation	on (in)		4	9	12			
	Amount A	applied (199	22 MT) ²	2	345	12,000				
	Methods of Incorporation: Disking (13) Subsurface Injection (1) Springtooth Harrow (1)									
	# of Land	Treatment	Units: 15	·····						
				Aquifer Inform	ation					
	Depth to	Aquifer (ft)		6	15.5	97				
	Distance t	o Private V	Vell (ft)	3,000	4,390	10,000				
	Population	Using Pri	vate We <u>ll</u>	1	150.5	300				
	Distance t	o Public W	'ell (ft)		7,920	34,325	52,800			
	Population	Using Put	olis Well		-		-			
	# of Aqui	fers: 13								
	Source: Unreporte Uppermon Lowermon Combinat									
	1	Classification of Uppermost Aquifer: Current of potential source of drinking water (3) Not considered a potential source of drinking water (9) Unreported (1)								

Table	Table 3.1.9. Management Practices Targeted for Risk Assessment							
	Unleaded Gasoline Tank Sediment							
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)	
Onsite and Offsite Subtitle D Landfill ^{1,3,4}	18	31	7	633.4		6.25	72.7	
			Onsi	e Landfill Char	racteristics		•	
	Surface A	rea (acres)			3.7	7.5	36	
	Remaining	Capacity	(cu.yd.)		25,088	80,000	6,500,000	
	Percent Re	emaining C	apacity		0.7	12	25	
	Total Cap	acity (cu.yo	i.)		85,000	168,950	8,000,000	
	Number o	f Strata in	Completed Unit		0	5.25	400	
	Depth Bel	ow Grade	(ft)		0	6	15	
	Height Ab	ove Grade	(ft)		3	13	72	
	# of Land	fills: 6						
				Aquifer Inform	ation			
:	Depth to A	Aquifer (ft)			8.5	12	166	
	Distance to	Private V	Vell (ft)		2,500	2,500	2,500	
	Population	Using Pri	vato Well	2	2	2		
	Distance to	Public W	'ell (ft)		15,840	15,840	15,840	
	Population	Using Pul	olic Well		-		-	
	# of Aquif	ers: 6						
	Source: Public Private Unreported 3 5 Combination 3 1							
	c	urrent of p	ermost Aquifer: otential source o red a potential so			***		

¹ The number of onsite land treatment units and landfills characterized in Table 3.1.9 is greater than indicated in Table 3.1.7 which focuses only on volumes generated in 1992. Table 3.1.9 incorporates data, respectively, from all onsite land treatment units, and all onsite landfills, receiving unleaded tank sediment in any year reported in the §3007 survey.

² Volumes represent the average volume of all wastes applied to the land treatment units accepting the unleaded tank

sediment and not just the tank sediment alone.

³ The mean and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream from one refinery may be disposed of in one management unit causing the 90th percentile number actually to be the sum of 2 or 3 waste volumes).

Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.1.2.3 Characterization

Due to the small amount of sediment typically generated during turnaround and, at times, the absence of sediment, samples of unleaded gasoline sediments were very difficult to obtain. The number of refineries chosen for record sampling was expanded to increase the availability of these hard-to-find residuals; however, the newly targeted facilities did not increase the procurability of unleaded tank sediment.

Two sources of residual characterization were developed during the industry study:

- Table 3.1.10 summarizes the physical properties of the tank sediment as reported in Section VII.A of the §3007 survey.
- Three samples of unleaded gasoline tank sediment were collected. These samples were collected after the tanks had been water-washed. Table 3.1.11 provides the location and description of the samples collected.

Table 3.1.10. Unleaded Gasoline Tank Sediment Physical Properties								
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %			
pH	109	172	5.2	7.5	10			
Reactive CN, ppm	57	224	0	30.25	50			
Reactive S, ppm	65	216	0	41.7	125			
Flash Point, °C	77	204	20	57. 7	93			
Oil and Grease, vol %	77	204	0.5	10.81	20			
Total Organic Carbon, vol %	44	237	0	11.1	20			
Specific Gravity	68	213	1.0	1.4	2.27			
BTU Content, BTU/lb	27	254	100	4,088	16,155			
Aqueous Liquid, %	156	125	0	23.9	70			
Organic Liquid, %	150	131	0	7.31	20			
Solid, %	190	91	20	72.8	100			
Particle >60 mm, %	22	259	0	25.2	89			
Particle 1-60 mm, %	24	257	0	46.4	100			
Particle 100 μm-1 mm, %	23	258	0	35.3	100			
Particle 10-100 μm, %	19	262	0	13.7	50			
Particle < 10 μm, %	19	262	0	7.9	50			
Mean Particle diameter, microns	12	269	0	1,294	500			

Table 3.1.11. Unleaded Gasoline Sediment Record Sampling Locations							
Sample Number Location Description							
R6B-US-01	Shell, Norco, LA	Water-washed solids: collected by refinery					
R8A-US-01	Amoco, Texas City, TX	Water-washed solids: collected by refinery					
R16-US-01	Koch, St. Paul, MN	Drummed, dry, light-brown, water- washed solids					

The 3 samples collected are believed to be representative of the industry. Table 3.1.12 provides the characterization data for this sampling effort. Only constituents detected in at least one sample are shown in this table. Of the 3 unleaded gasoline sediment samples collected, one sample exhibited the toxicity characteristic for benzene. Unleaded gasoline tank sediment has a low organic content because the tank is water-washed prior to tank entry. High iron concentrations can be attributed to the rust and scale of the tank.

3.1.2.4 Source Reduction

As with crude oil tank sediments, mixers have reduced the volume of sediment generated. The mixers are used to suspend the solids in the product, reducing the amount of solids that may settle to the bottom of the tank.

50% of unleaded gasoline storage tanks have mixers

Table 3.1.12. Unleaded Gasoline Storage Tank Sediment Characterization

							1	10% Confidence	
	Voiatile Organics	 Method 8260A; 	⊿g/kg					interval	
	CAS No.	R68-US-01	R8A-US-01			Maximum Conc	Std Dev	Upper Limit	Commerts
Benzene	71432	43,000	110,000 J		61,900	110,000	54,201	110,918	2
n-Butylberzena	104518	73,000	210,000	77,000	120,000	210,000	77,968	204,898	
sec-Buty benzene	135988	J 12,000		7,800	14,033	25,000	8,967	24,698	
Etrylbenzene	100414	290,000	450,000	58,000	266,000	450,000	197,099	480,618	2
Isopropylbenzens	98828	27,000		11,000	21,000	27,000	8,718	30,493	2
n-Propy@enzere	103851	130,000	230,000	38,000	32,667	230,000	96,02B	237,230	2
Toluene	108883	690,000	, 740,000	85,000	505,000	740,000	364,589	901,994	2
1,2,4 – Trimethybenzene	95636	740,000	1,300,000	400,000	813,333	1,300,000	454,450	1,308,180	2
1,3,5 - Trimethybenzene	108678	230,000	460,000	160,000	283,533	460,000	156,950	454,234	
o~Xylene	95476	440,000	640,000	240,000	440,000	540,000	200,000	657,777	2
m,p-Xylenes	106383 / 106423	1,400,000	1,300,000	510,000	1,103,533	\$,400,000	430,155	1,571,722	2
Nephthelene	01203	170,000	350,000	190,000	230,057	350,000	98,658	344,093	2
	***************************************						ı	10% Confidence	
	TCLP Votable On	ganica Methoda	1311 and 8260A	μg/L`				Interval	
	CAS No.	R68-US-01	RBA~US-DI	R16-LB-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
Nethylene chloide	75002	< 50	150 <		63	150	58	145	
Benzene	71432	600	1,600 J	65	752	1,600	784	1,505	2
Etrylbenzene	100414	1,100	1,500	290	963	1,500	616	1,635	2
n-Propylibenzene	103651	240	270 J	50	190	270	114	314	2
Toluene	108883	1,700	6,000	950	3,550	8,000	3,872	7,768	
12,4-Trimethybenzene	95635	1,500	2,300	1,200	1,567	2,300	569	2,266	
1,3,5—Trimethybenzene	108678	560	700	300	520	700	203	741	2
o-Xylene	95476	1,900	3,000	1,400	2,100	3,000	819	2,991	
m.pXylene	108383 / 105423	3,200	6,100	2,700	4,000	6,100	1,836	5,999	
Nephthelene	01203	920	1,000	. 540	853	1,000	189	1,059	2
	Semivolatile Orga	ancs – Method åž	2708 <i>µe</i> /kg				ı	i0% Contidence Interval	
	CAS No.	R68-US-01		R18-LS-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
Acenephthene	63329	J 780) 9 00]J	250	643	900	346	1,020	2
Anthrecene	120127	J 760	< 1,650 <	165	463	760	421	1,378	1,2
Bis(2-ethylhexyl)phthalate	117817	7,600	< 1,650 <	105	3,138	7,600	3,035	7,429	
Indene	95135	42,006	72,000 J	620	38,297	72,000	35,699	77,189	2
Flucture	86737	J 1,400	J 1,800 <	185	1,122	1,800	852	2,050	2
Phenanthrene	65018	J 2,400	1,400 <	185	1,322	2,400	1,120	2,541	2
Pyrene	129000	J 930	< 1,650 <	, , , ,	548	930	541	1,725	1,2
1-Methylnaphthalene	90120	140,000	150,000	17,000	102,333	150,000	74,070	182,967	2
2-Methylnsphthalene	91576	260,000	310,000	000,60	222,667	310,000	110,821	343,338	2
Naphthalene	91203	190,000	400,000	49,000	213,000	400,000	170,627	405,325	2

UNLEADED GASOLINE TANK SLLIDGE

7439896	550.0	210.0	3.6	254.0	550.0	275.8	554.0	2
CAS No.	R458-U6-01	R8A-US-01		Average Conc		Std Dev	Upper Limit	Commer
CLP Metata - Ma							Interval	
							90% Confidence	
							•	
7440666	190.0	3,300.0	71.	1,187.0	3,300.0	1,830.0	3,160.6	
7440622	< 50.0	73.0	< 55.	59.3	73.0	12.1	72.5	
7440020	550.0		4,900.		4,900.0	2,677.6	4,738.0	
7439987	14.0	1			70.0	28.5	61.0	
7439976	0.10	0.27	0.1		0.27	0.09	027	
7439965	1,300.0	1,500.0	-		2,400.0	585.9	2,371.4	~
7430021	280.0	280.0	260.		260.0	11.5	285.9	2
7439896	340,000.0	350,000.0	650.00		550,000	118,462	542,325	
7440508	2500	220.0	210		250.0	20.6	249.3	
7440484	20.0				55.0	18.9	53.9	
7440473	0.00	99.0			140.0	25.6	138.5	
7440430					5.5	2.1	5.4	
7440382	35.0	240.0	< 65.		240.0	24.4 123.9	64.3 232.2	
7440300			-,		2,000 65,0	1,026	1,644	
7429905	iu-su-sun laase						Upper Limit	Comma
otai Metale – Me CAS No.		U, 7421, 747U, 7. RBA-US-01		ngung 1 Average Conc	Marin m Cana	Std Dev	Interval	.
'otal Motala — lida	d	0 7404 7420 7	474 au - 17044 a				90% Confidence	
								,
91203	780	830	64	D) 750	830	9 8	£57	2
91570	320	500	40	-1	400	101	416	2
90120	190		21	1	210	59	230	2
95130	390					192	381	
NA	160	180				70	206	2
95487	150	160			160	61	186	2
105679	120	130			130	52	152	2
117817	370	< 50			370	185	358	
	P69-U6-01		R16-US-0	 Average Conc 	Meximum Conc	Std Dev	Upper Umit	Comme

Comments:

- 1 Detection limits greater han the highest detected concentration are excluded from the calculations
- 2 Upper Limit exceeds the maximum concentration.

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

Bla(2-ethyhexyliphthalate 2,4-Olmethylphanol 2-Methylphanol 3,4-Methylphanol Indene 1-Methylmaphthalana 2-Methylmaphthalana Naphthalana

Aluminum
Antimory
Antenio
Cadmium
Chromium
Cobett
Copper
Iron
Lead
Mengenese
Mercury
Molybdenum
Nickel
Venedium
Zinc

iron Lead Manganese Nickel Zinc

ignitability (oF)

3.1.3 Clarified Slurry Oil Tank Sediment and Filter Solids - Residual 3

Clarified slurry oil is the bottom fraction from fluid catalytic cracking units, operated at 109 refineries. In 1992, U.S. refineries reported 297 dedicated clarified slurry oil (CSO) tanks with an average capacity of 45,000 barrels and 111 storage tanks with an average capacity of 55,000 barrels with commingled CSO and residual fuel oil.

3.1.3.1 Description

CSO is the lowest boiling fraction off the FCC's main fractionator (see Section 3.2 for FCC process description). The CSO contains some catalyst and catalyst fines (1-2 wt%). Some refineries have a slurry settler that removes up to 50% of these fines and returns them to the process. The top draw off the settler, CSO, is sent to a storage tank, where most of the remaining solid catalyst particles settle out, forming a sediment at the bottom of the tank. The tank sediment also contains rust. The CSO is sold as carbon black feedstock, residual fuel oil or bunker fuel. CSO sediment is generated in 3 ways: tank bottoms, filter solids, and during FCC unit cleanout\turnaround.

CSO tank bottoms are generated every 5-10 years during storage tank cleanout. As with crude tank sediment, many refineries use in situ and ex situ oil recovery techniques. Common in situ oil recovery techniques include hot distillate washing and steam stripping. These techniques allow entrapped oil to float to the top of the sediment for recovery prior to removal from the tank. Ex situ recovery methods, usually performed by a contractor at the tank site, include filtration, centrifuging, and settling. Separated oil is recycled back to the process or sent to the slop oil tanks; any water is sent to the WWTP. The solids are managed in a variety of ways including disposal at Subtitle C and D landfills and in land treatment units. It is not unusual for the sediment to be stabilized by using clay or kiln dust to soak up any remaining free oil.

Mixers are also installed on CSO tanks to reduce tank bottom buildup. Mixers keep the catalyst fines suspended in the CSO.

28% of the tanks that store CSO have mixers

Some refineries filter their CSO prior to storage.

Cartridge filters are employed to remove catalyst fines which are entrained in the product.

Filtered solids are generated once or twice a year, depending on product volume.

Every 2 to 3 years, the FCC is shutdown for turnaround. At this time, sediments may also be generated in the process equipment (e.g., hydroclone).

In 1992, approximately 1 percent of the volume of CSO sediment generated was reported to be managed as hazardous.

3.1.3.2 Generation and Management

The refineries reported generating approximately 24,010 MT of CSO sediment in 1992. Residuals were assigned to be "CSO sediment" if they were assigned a residual identification code of "FCC CSO tank sediment," "FCC CSO sediment, other than tank sediment," or "Other tank sediment/CSO [commingled]." These correspond to residual codes 01-D, 02-C, and 01-E, respectively, in Section VII.2 of the questionnaire. Process wastewaters, decantates, and recovered oils (e.g., from deoiling or dewatering operations) were eliminated from the analysis. These correspond to residual codes 09, 10, and 13 (new) in the questionnaire. Quality assurance was conducted by ensuring that all CSO tank sediments previously identified in the questionnaire (i.e., in Section V.D) were assigned in Section VII.2. Table 3.1.13 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.1.13. Generation Statistics for CSO Sediment, 1992								
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)			
Discharge to onsite WWTP	1	0	250	250	250			
Disposal offsite Subtitle D landfill	16	0	11,341	709	2,871*			
Disposal onsite Subtitle D landfill	2	0	679	339.5	619			
Disposal offsite Subtitle C landfill	9	1	3,564	396	2,278			
Offsite land treatment	2	0	2,389	1,195	2,278			
Onsite land treatment	4	1	2,906	726.5	2,520			
Onsite industrial furnace	1	O	39	39	39			
Transfer for use as fuel	3	0	1,850	617	1,724			
Recovery/reuse onsite	2	2	581	290.5	381			
Other recycling/onsite road material	2	0	411	205.5	314			
Total CSO sediment	42	4	24,010	572	1,724			

^{*} Outlier quantities confirmed in §3007 survey.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.1,13 were reviewed

¹ Reuse onsite includes recovery in catalytic cracker, coker, distillation unit or in asphalt production.

to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite land treatment (used for 12% of sediments)
- Offsite Subtitle D landfilling (47% of sediments)
- Onsite Subtitle D landfilling (3% of sediments)

An onsite monofill scenario was rejected because of the intermittent (every 10 years) generation frequency, which is not typical of wastes that tend to be monofilled.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.1.14.

Table 3.1.14. Selection of Risk As	sessment Modeling Scenario: CSO Sediment
Waste	Basis for Consideration in Risk Assessment
Discharge to onsite WWTP	Not modeled. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be captured by existing hazardous waste listings and further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.
Disposal offsite Subtitle D landfill	Modeled
Disposal onsite Subtitle D landfill	Modeled
Disposal offsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control
Recovery/reuse onsite	Proposed excluded management practice
Offsite land treatment	Modeled
Onsite land treatment	Modeled
Transfer for use as fuel	Not modeled. Already regulated if characteristic.
Onsite industrial furnace	Not modeled. Minimal volume, unlikely to significantly impact emissions due to dilution. Already regulated if characteristic.
Other recycling/onsite road material	Similar application of much larger volume modeled under land treatment scenario.

The Agency evaluated whether it was necessary to model short-term on-site storage of CSO sediment prior to final management. Using the same logic described in the earlier discussion of the selection of management practices to be modeled for crude oil tank sediment, EPA determined that the potential for contaminant release and exposure at levels of concern was insignificant in comparison with the long-term risks associated with landfilling and land treatment. Therefore, on-site storage was not modeled in the Agency's risk assessment.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.1.15 provides a summary of the data for the targeted management practices used in the risk assessments for the CSO sediments. Appendix C summarizes §3007 data regarding runon/runoff controls used for these units.

As with crude oil tank sediment, many refineries conduct de-oiling of CSO tank sediment, both before and after removal from the storage tank. The Agency evaluated whether de-oiling has any impact on the risks associated with the disposed sediment. The Agency hypothesized that de-oiling might reduce toxicant concentrations for certain toxicant fractions (e.g., volatiles), although others could be concentrated (e.g., metals). Samples were collected of sediments with and without de-oiling after removal from the storage tanks (described further in Section 3.1.3.3). As discussed earlier in Section 3.1.1.2, after considering all of these factors, the Agency determined that differentiating between oily and de-oiled sediments was inappropriate. De-oiling reduces volume, which, if all other factors were held constant, would tend to reduce the risk modeled. The average de-oiled crude oil tank sediment volume is 514, while the average oily sediment volume is 384. De-oiled sediments are predominantly disposed of in offsite Subtitle D landfills (39%), disposed of in offsite Subtitle C landfills (30%), or sent to offsite land treatment (21%). Oily sediments are more likely to be disposed of in offsite Subtitle D landfills (53%), sent to offsite land treatment (22%), or transferred offsite for use as a fuel (14%).

Table 3	3.1.15. N	1anagen	nent Practice	s Targeted	for Risk	Assessmen	<u> </u>
			CSO Sedi	ment			
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Onsite and Offsite Subtitle D Landfill ^{3,4}	13	18	0	12,020	***	184.5	3,143
			Onsite 1	Landfill Char	racteristics		
	Surface A	√ea (acre:	s)		0.4	30	250
	Remainin	Remaining Capacity (thousand cu.yd.) 3.1 83					
	Percent R	emaining	Capacity	2	40	80	
	Total Car	acity (the	usand cu.yd.)		3.2	840	11,100
	Number o	of Strata i	n Completed Un	it	0	5,5	11
	Depth Be	low Grade	s (ft)		8	29	<i>5</i> Q
	Height A	bove Grad	le (ft)		0	1.25	2.5
	# of Land	fills: 2	·	· · · ·			
			Ac	quifer Inform	ation		, ,
	Depth to	Aquifer (ft)		39	62	85
	Distance	to Private	Well (ft)		8,970	8,970	8,970
	Populatio	n Using F	rivate Well		-	•	₩
	Distance	Distance to Public Well (ft) 58,000 58,000 58,000					
	Population Using Public Well 1,500 1,500 1,500						1,500
	# of Aqui	# of Aquifers: 2					
	Source: Unreporte Uppermo: Lowermo	st	<u>Public</u> 1 - 1	<u>Priva</u> ! 1 	<u>te</u>		
	N	lot consid	ppermost Aquife ered a potential : potential source	source of dri		(1)	

Table 3.1.15. Management Practices Targeted for Risk Assessment								
CSO Sediment								
Offsite Land Treatment Unit	2	2	0	2,389	4-7-18	1,194.6	2,277.75	
Onsite Land Treatment Unit ^{1,3}	5	4	1	2,905		190.95	2,520	
Treatment Onli-				Characteristi	cs		:	
	Surface A	rea (acres	s)		8.8	15	170	
- Anna Anna Anna Anna Anna Anna Anna Ann	Depth of	Іпсогрога	tion (in)		6	10	13.5	
	Amount A	Applied (1	992 MT)²		4	735	15,322	
	Methods	Methods of Incorporation: Disking (7) Subsurface Injection (1) Springtooth Harrow (1)						
	# of Lanc	lfills: 9					_	
			A	quifer Inform	ation			
	Depth to	Aquifer (1	ft)		12.5	16.75	265	
	Distance	to Private	Well (ft)		1,000	6,200	25,000	
	Populatio	n Using P	rivate Well		300	300	300	
	Distance	to Public	Well (ft)		6,500	13,200	25,000	
	Populatio	n Using P	ublic Well		****	WeAVE		
	# of Aqui	# of Aquifers: 8						
	Source: Unreporte Uppermo Lowermo Combinat	st st	<u>Public</u> 5 2 1 		Private 3 3 2 —			
		urrent or	ppermost Aquife potential source ered a potential	of drinking v		(5)		

¹ The number of onsite land treatment units characterized in Table 3.1.15 is greater than indicated in Table 3.1.13 which focuses only on volumes generated in 1992. Table 3.1.15 incorporates data from all onsite land treatment units receiving sediment in any year reported in the §3007 survey.

² Volumes represent the average volume of all wastes applied to the land treatment units accepting the CSO sediment and not just the sediment alone.

³ The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

⁴ Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.1.3.3 Characterization

Since the industry varies management methods, the sampling profile reflects the fact that about half of the refineries do some sort of oil recovery prior to sediment disposal. As with most tank sediments, CSO sediment from tanks is available only during turnarounds, which occur every 5 to 10 years. CSO filters are generated more frequently, however, only one of the refineries selected for record sampling uses filters.

Two sources of residual characterization were developed during the industry study:

• Table 3.1.16 summarizes the physical properties of the CSO sediment as reported in Section VII.A of the §3007 survey.

Table 3.1.16. CSO Sediment Physical Properties								
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %			
pН	53	68	5	5	7.8			
Reactive CN, ppm	29	92	0.02	26.4	250			
Reactive S, ppm	35	86	1	91	250			
Flash Point, °C	42	79	60	84.1	100			
Oil and Grease, vol%	44	77	5	29.5	80			
Total Organic Carbon, vol %	15	106	. 5	29	70			
Viscosity, lb/ft-sec	3	116	0.14	666	1,000			
Specific Gravity	41	80	1	1,4	2.1			
BTU Content, BTU/lb	36	85	2,000	5,935	3,000			
Aqueous Liquid, %	62	59	0	11.4	50			
Organic Liquid, %	71	50	0	25.7	70			
Solid, %	83	38	20	69.7	100			
Particle >60 mm, %	6	115	0	16.7	100			
Particle 1-60 mm, %	15	106	0	29.4	100			
Particle 100 μm-1 mm, %	13	108	0	60.6	100			
Particle 10-100 μm, %	13	108	o	28.5	45			
Particle < 10 μm, %	6	115	0	0	0			
Mean Particle diameter, microns	8	112	2.5	612.5	800			

• Due to the rarity of sediment generation, only 4 samples were available during record sampling. These included 1 oily tank sediment sample, 1 composite sample of both oily and de-oiled sediment, 1 de-oiled tank sediment sample, and 1 CSO filter. These sediments represent the various types of oil recovery typically used by the industry. Table 3.1.17 provides the sample location and description.

The 4 samples collected are believed to be representative of the sediment as generated. Table 3.1.18 provides a summary of the characterization data collected under this sampling effort. Only constituents detected in at least one sample are shown in this table. Of the CSO sediment samples collected, none exhibited the toxicity characteristic. The high aluminum content can be attributed to the FCC catalyst which makes up a majority of the solids in the sediment.

	Table 3.1.17. CSO Sediment Record Sampling Locations							
Sample #	Location	Description: Oil Recovery						
R9-SO-01	Murphy, Superior, WI	CSO filter						
R1B-SO-01	Marathon, Indianapolis, IN	CSO, classified as residual oil by refinery: oily and stabilized with cement kiln dust						
R4-SO-01	Little America, Casper, WY	Tank sediment de-oiled through settling						
R20-SO-01	Star Enterprise, Convent, LA	Centrifuged sediment						

3.1.1.4 Source Reduction

In situ oil recovery techniques can greatly reduce the total volume of CSO tank sediment to be disposed. As discussed above, recovery methods include distillate washing, nonpetroleum solvent washing, water wash with surfactant, and steam stripping. This allows entrapped oil to float to the top and be recovered prior to removal from the tank. Separated oil is recycled back to the process or sent to the slop oil tanks, and the water phase is sent to the WWTP.

As with crude oil, tank bottom buildup may be reduced by installing mixers. Mixers keep the sediments or solids continuously in suspension so that they travel with the CSO. However, these solids may drop out later in the process, resulting in greater sediment generation at turnaround and possibly more frequent turnarounds.

Another method to reduce catalyst in the CSO is to install high-efficiency cyclones in the FCC reactor. This can shift the catalyst fines losses from the reactor to the regenerator where the fines can be collected in the electrostatic precipitator or wet gas scrubber (note that not all refineries are in States that require air pollution control on their FCCs). API estimated that 2 pounds of tank bottoms are prevented for every pound of catalyst exiting the regenerator instead of the reactor (see FCC unit process flow diagram) (API, 1991).

Some refineries have a slurry settler that removes up to 50% of the catalyst fines in the CSO and returns them to the process. By adding a settler to the FCC unit, sediment-forming solid catalyst particles can be greatly reduced.

Table 3.1.18. CSO Sediment Characterization

								1	90% Confidence	
	Volatile Organics								interval	
	CAS No.	R4-SO-01		A1E-SO-01			Maximum Conc	Std Dev	Upper Limit	Comments
Acetone	67541	< 1,250					3,400	1,202	2,653	
, Benzene	71432	< 1,250			< 2,500		1,200	NA	NA	1
n-Bulyibenzene	104518	< 1,250		17,000	22,000		22,000	10,579	10,177	
sec-Bulyibenzene	135958	< 1,250	1	2,600	J 5,000		3,000	1,117	2,784	
Ethylbenzare	100414	< 1,250	4,300	12,000	20,000	9,388	20,000	8,397	18.265	
h opropylbenzene	96826	< 1,250	< 625	J 2,300	J 2,900	1,789	2,900	1,023	2,607	
p-teopropyttoluene	99676	< 1250	< 525	2,600	J 2,500	1,789	2,600	963	2,562	
Naphthalene	91203	2,900	11,000	19,000	E 140,000	43,225	140,000	64,651	98,338	
n-Propylbenzere	103661	< 1,250	2,700	< 1,250	< 2,500	1,926	2,700	784	2,567	
Toluene	108863	3,000	8,700	13,000	17,000	10,850	17,000	5,834	15,264	
1,2,4—Trimethylbenzene	95836	11,000	20,000	25,000	E 140,000	49,000	140,000	80,943	60,912	
1,3,5—Trimethyltmazone	108878	2,000	5,600	35,000	42,000	21,300	42,000	20,103	57,764	
a - Xviene	95476	3,000	7,500	27,000	40.000	19,376	40.000	17,250	53,503	
m.p.—Xylenes	106363 / 106423	11,000	19,000	69,000	100,000	49,750	100.000	42,201	84,313	
in a significant				,,				,,	- 4	
								!	90% Confidence	
	TCLP Voistle Or		ds 1311 and 826						in terve)	
	CAS No.	R4-80-01		R18-80-01	R20-SO-0	i Average Cond	Meximum Conc	Std Dev	Upper Limit	Comments
Acetone	67641	≺ 50	< 50	B 360	< 50		300	155	254	
Berutene	71432	< 50	J 84	< 50	< 5) 50	54	17	72	
Methylane chlorida	75092	< 50	< 50	.#B 90	J e	70	. 20	23	89	
Nazirthalana	91203	< 50	< 50	140	200	110	200	73	170	
Taluerie	108683	B 260	180	150	3 8	176	240	74	235	
1,2,4-Trimethylbenzene	95838	< 50	< 50	1 110	10	76	110	32	104	
o-Xviene	95478	8 110		110	J 6	63	110	32	100	
m,p-Xylene	106363 / 106423	_			10	190	250	73	250	
m'h – Vàinne	, (55-24		, ,	1 2001	***	1		1.41	2001	
nt,p-xylene		0 100	, , , ,	1 200	,,,,,	, ,	•	- 1	90% Confidence	
п.р.— Хумиче	Semivolatile Org		,	1 2001	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,, 100	a vo ș	- 1	•	
at, p = Ayeese			1 8270B µg/kg	,,		•	Maximum Conc	- 1	90% Confidence	Comments
	Semivolatile Org CAS No.	anics — Method R4-80-01	' 18270В µg/kg R9-80-01	R18-SO-01		i Average Cond	Maximum Conc	,	90% Confidence Interval	Comments
Acensphinens	Semivolatile Org CAS No. 83329	nnics — Method R4—90-01 < 01,875	1 82708 µg/kg R9-80-01 46,000	#19-SO-01 53,000	R20- SO-0	1 Average Cond	Maximum Cone 180,000	Std Dev 53,583	90% Confidence Interval Upper Limit	Comments
Acensphthane Anthracens	Semivolatile Org CAS No.	anics Method R4-80-01 < 01,875 < 01,875	62706 µgkg R9-80-01 46,000 77,000	#18-SO-01 53,000 J 32,000	R20- SC -0 180,000 60,000	1 Average Cond 60,219 64,219	Maximum Conc 150,080 86,000	Std Dev 53,563 23,674	90% Confidence Interval Upper Umit 124,103	Comments
Acensphthens Anthracers Benz(a)anthraces	Semivolatile Org CAS No. 53329 120127 56553	enios — Method R4—80-01 < 61,575 < 61,575 380,000	182708 µgkg R9-80-01 48,000 77,000	RIB-SO-01 53,000 J 32,000 < 20,625	R20- SC -0 180,000 66,000	Average Cond 80,219 64,219 202,966	Maximum Conc 180,080 86,090 390,080	Std Dev 53,583 23,674 199,200	90% Confidence Interval Upper Limit 124,103 63,807 369,113	Comments
Acensphthene Anthracene Benzofiuoranthene (total)	Semivolatile Org CAS No. 83329 120127 56533 NA	enios — Method R4-90-01 < 01,875 < 01,875 380,000 J 110,000	182708 µgkg R9-80-01 48,000 77,000 200,000	#18-SO-01 53,000 J 32,000 < 20,025 J 27,000	R20-SO-8 160,000 66,000 41,256 J 60,000	Average Cond 80,219 64,219 202,969 76,750	Maximum Conc 180,080 86,080 390,080 110,080	Std Dav 53,583 23,674 199,200 40,689	90% Confidence Interval Upper Limit 124,103 63,807	
Acensphthens Anthracens Benz(a)anthracens Benzo(tuoranthens (total) Benzo(g,h.l)pssylens	Semivolatile Org CAS No. 80329 120127 56533 NA 191242	enios — Method R4-970-01 < 81,975 < 61,975 380,000 J 110,000 J 90,000	182708 µgkg R9-60-01 46,000 77,000 200,000 110,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000	R20-SO-0 180,000 66,000 41,25 J 60,000 J 63,000	Average Cond 80,219 64,219 202,966 78,750	Maximum Cone 180,000 86,000 390,000 110,000	Std Dav 53,583 23,674 199,200 40,689 34,419	90% Confidence Interval Upper Limit 124,103 63,607 366,113 110,074 87,189	
Acensphthene Anthracene Benz(a)anthracene Benzo(athracene) Benzo(a,h.)pseylene Benzo(a)pyrene	Semivolatile Org CAS No. 83329 120127 58553 NA 191242 50328	enios — Method R4-90-01 < 01,975 < 01,975 380,000 J 110,000 J 90,000	1 82708 µg/kg R9-50-01 46,000 77,000 300,000 110,000 100,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 52,000	R20-SO-8 150,000 66,000 41,256 J 60,000 J 63,000 J 76,000	Average Cond 80,219 84,219 202,969 78,750 99,000	Maximum Conc 190,000 85,000 390,000 110,000 130,000 230,000	Std Dev 53,583 23,874 199,200 40,689 34,419 82,833	90% Confidence Interval Upper Limit 124,103 63,607 366,113 110,074 87,189 189,640	2
Acensphthene Anthracens Benz(a)anthracens Benzo(tuoranthene (total) Benzo(a).hipseylane Benzo(a)pyrene Carbazote	Semivolatile Org CAS No. 83329 120127 56353 NA 191242 50326	enios - Method R4-80-01 < 81,875 < 91,875 380,000 J 110,000 J 90,000 230,300 < 123,750	1 82708 µg/kg R9-90-01 46,000 77,000 360,000 110,000 170,000 87,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 52,000 < 41,250	R20-SO-8 180,000 68,000 4 1,255 J 60,000 J 63,000 J 76,000 J 67,000	Average Conc 80,219 64,219 202,969 76,750 96,000 132,000 65,063	Maximum Conc 190,000 86,000 390,000 110,000 190,000 230,000 87,000	Std Dav 53,583 23,874 199,200 40,689 34,419 82,833 22,835	90% Confidence Interval Upper Limit 124,103 63,607 369,113 110,074 97,189 189,640 90,057	
Acensphthene Anthracere Benz(a)enthracese Benzo(uc)anthere (total) Benzo(a)th/perylene Benzo(a)pyrene Carbazole Chysene	Semivolatile Org CAS No. 89329 120127 56853 NA 191242 50326 66748	enios - Method R4-90-01 4-87-01 5-81,875 380,000 J 110,000 J 90,000 230,000 4 123,750 700,000	18270В µg/kg R9-80-01 46,000 77,000 390,000 110,000 170,000 87,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 52,000 < 41,250 170,000	R20-SO-0 150,000 66,000 41,255 J 60,000 J 63,000 J 67,000 J 220,000	Average Conc 80,219 94,219 202,999 76,750 95,000 132,000 65,083 487,500	Maximum Cone 190,000 86,000 390,000 110,000 130,000 230,000 87,000 860,000	Std Dav 53,583 23,874 199,200 40,689 34,419 82,833 22,835 344,813	90% Confidence Interval Upper Limit 124,103 63,007 360,113 110,074 87,189 189,640 90,657 769,736	2 1, 2
Acensphthens Anthracers Benz(e)anthracers Benzo(tucianthers (total) Benzo(g,h.):psylins Benzo(a)pyrens Carbatols Chysens Dibenz(a,h)anthracens	Semivolatile Org CAS No. 80329 120127 56553 NA 191242 50326 60748 218019	anios - Method R4-80-01 < 61,875 360,000 J 110,000 230,000 < 123,750 700,000 < 61,875	R9-60-01 - 46,000 - 77,000 - 300,000 - 110,000 - 170,000 - 87,000 - 880,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 52,000 < 41,250 170,000 < 20,625	R20-\$C-8 150,000 66,000 41,25i J 63,000 J 67,000 J 67,000 220,000 < 41,25i	Average Cond 80,219 94,219 202,989 78,750 9,000 132,000 45,083 447,500	Maulmum Cone 180,000 86,000 390,000 110,000 130,000 87,000 880,000 49,000	Std Dev 53,563 29,874 199,200 40,889 34,419 82,933 22,183 344,813	90% Confidence Interval Upper Limit 124,103 63,807 369,113 110,074 97,189 199,840 90,057 769,736 62,626	2 1,2 1,2
Acensphthene Anthracene Benz(a)anthracene Benzo(iusanthene (total) Benzo(g.h.)pseylane Benzo(a)pyrane Carbazole Chysene Dibenzo(n,h)enthracene	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 66748 218019 53703	anios - Method R4-90-01 < 61,875 < 61,875 360,000 J 110,000 J 90,000 < 123,750 700,000 < 61,875 < 61,875	182708 µg/kg R9-80-01 46,000 77,000 360,000 110,000 170,000 87,000 880,000 49,000 21,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 52,000 < 41,250 170,000 < 20,625 J 31,000	R20-SC-8 160,000 66,000 41,255 J 65,000 J 76,000 J 77,000 220,000 41,255 J 37,000	1 Average Conc 80,219 64,219 202,989 78,750 65,083 467,500 90,985 90,987	Maximum Conc 190,000 85,000 390,000 110,000 130,000 230,000 87,000 890,000 49,000 37,000	Std Dev 53,863 23,874 199,200 40,889 34,419 82,933 22,835 344,813 14,800 8,863	90% Confidence Interval Upper Limit 124,103 63,807 389,113 110,074 67,189 189,840 90,057 789,736 62,926 38,488	2 1, 2
Acensphthene Anthracens Senz(a)anthracens Senzo(a,h,fpeepinne Senzo(a,byrene Carbazote Chysene Dibenz(a,h)anthracens Dibenz(a,h)anthracens 7,12-Dimathylbenz(a,bnitracens	Semivolatile Org CAS No. 80329 120127 56853 NA 191242 50326 66748 218019 53703 132649 57676	anios - Method R4-80-01 < 61,875 < 61,875 360,000 J 110,000 230,000 < 123,750 700,000 < 61,875 < 61,875	182708 µg/kg R9-80-01 46,000 77,000 360,000 110,000 10,000 87,000 87,000 49,000 1,200,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625	R20-SO-8 180,000 60,000 41,255 J 63,000 J 76,000 220,000 < 41,255 J 37,000 < 41,255	1 Average Conc 80,219 64,219 202,960 76,750 69,000 132,000 65,083 487,500 30,956 29,667 330,636	Maximum Cone 180,000 86,000 390,000 110,000 130,000 87,000 880,000 49,000 37,000 1,200,000	Std Dev 53,563 23,874 199,200 40,869 34,419 52,933 22,935 344,913 14,690 6,963 579,620	90% Confidence Interval Upper Limit 124,103 63,907 360,113 110,074 87,189 199,640 90,057 769,736 52,626 98,468 605,646	2 1,2 1,2
Acensphthene Anthracene Benz(e) enthracene Benzo((uc) anthracene Benzo(uc) anthracene Benzo(uc) anthracene Carbazole Chysene Dibenzo(uc) nuthracene Dibenzo(uc) anthracene Fluorenthene	Semivolatile Org CAS No. 83329 120127 56533 NA 191242 50326 66748 218019 53703 132049 57676	anios - Method R4-SO-01 < 61,875 380,000 J 110,000 230,000 < 123,750 700,000 < 61,875 < 61,875 J 43,000	8270В µg/kg R9-60-01 46,000 77,000 390,000 110,000 870,000 87,000 860,000 49,000 1,200,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000	R20-SO-8 180,000 66,000 41,256 J 63,000 J 67,000 J 07,000 < 41,256 J 37,000 < 41,256 J 49,000	Average Conc 80,219 94,219 202,999 78,750 9,000 65,083 467,500 90,856 29,867 330,636 62,500	Maximum Cone 190,000 86,000 390,000 110,000 230,000 87,000 860,000 49,000 37,000 1,200,000	Std Dev 53,563 23,974 199,200 40,689 34,419 82,933 322,835 344,913 14,600 8,963 579,920 45,158	90% Confidence Interval Upper Limit 124,103 63,807 369,113 110,074 87,189 189,840 90,657 789,736 62,626 38,468 805,844 100,056	2 1,2 1,2
Acensphthene Anthracers Senz(a)anthraces Senzof(ucanthers (total) Senzo(a,h,t)psyllene Senzo(a)pyrene Carbatole Chysene Dibenz(a,h)anthracene Dibenzofuran 7,12-Dimethylbenz(a)anthracene Fluoranthene	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 66748 218019 63703 132649 57676 206440	anios - Method R4-90-01 < 81,875 < 61,875 > 60,000 J 110,000 J 90,000 < 123,750 700,000 < 91,875 < 81,875 < 81,875 < 81,875 < 81,875	18270В µgkg R9-80-01 46,000 77,000 360,000 110,000 87,000 87,000 860,000 1,200,009 1,200,009 110,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000	R20-SO-8 186,000 66,000 41,255 J 60,000 J 76,000 J 776,000 < 220,000 < 41,256 J 37,000 < 41,256 J 49,000	Average Conc 80,219 94,219 202,980 78,750 9,000 132,000 65,063 497,500 9,085 29,667 330,636 62,500 111,460	Maximum Conc 190,000 85,000 390,000 110,000 230,000 87,000 890,000 49,000 37,000 1,200,000 200,000	Std Dev 53,983 29,974 199,200 40,889 34,419 82,933 22,935 344,813 14,900 8,963 579,920 45,150	90% Confidence Interval Upper Limit 124,103 63,007 380,113 110,074 97,189 189,840 90,057 789,736 52,626 38,488 805,844 100,058 162,623	2 1, 2 1, 2 1, 2
Acensphthene Anthracens Benz(a)anthraces Benzo(juoranthene (total) Benzo(a)pyrene Carbazole Citysene Dibenzoluren J. 12 – Dimethylbenz(a)anthracens Fluorene Indeno(1,2,2 – cd pyrene	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 66748 218019 53703 132649 57976 206440 86737	anios - Method R4-80-01 < 61,875 < 61,875 380,000 J 110,000 < 123,750 700,000 < 61,875 < 61,875 J 43,900 < 61,875 < 61,875 < 61,875	82708 μgkg R9-80-01 46,000 360,000 110,000 87,000 87,000 49,000 21,000 1,290,000 10,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 < 20,625	R20-SO-8 160,000 64,000 41,256 J 63,000 J 76,000 220,000 41,256 J 37,000 41,256 C 41,256 C 41,256	Average Conc 80,219 04,219 202,999 78,750 9,000 132,000 65,063 487,500 9,987 330,936 62,500 111,400 22,313	Maximum Cone 190,000 86,000 390,000 110,000 230,000 87,000 49,000 49,000 1,200,000 1200,000 200,000	Std Dev 53,963 23,874 199,200 40,989 34,419 82,933 22,135 344,813 14,600 8,983 579,820 45,158 62,456 3,801	90% Confidence Interval Upper Limit 124,103 63,607 369,113 110,074 87,189 169,640 90,667 769,736 62,626 98,468 905,646 100,056 162,823 31,565	1, 2 1, 2 1, 2 1, 2
Acensphthene Anthracene Benzo(gunthracene Benzo(gunthracene Benzo(gunthracene Benzo(gunthracene Carbazole Chysene Dibenz(gunthracene Dibenz(gunthracene Fluoranthene Fluoranthene Fluoranthene Indeno(1,2,3-cd[pyrene 3-Methylcholanthene	Semivolatile Org CAS No. 69329 120127 56853 NA 191242 50326 66746 218019 53703 13249 57676 206440 86737	anios - Method R4-80-01 < 81,875 >960,000 J 110,000 230,000 < 123,750 700,000 < 81,875 < 81,875 < 81,875 < 81,875 < 81,875 < 81,875	182708 µg/kg R9-80-01 46,000 77,000 260,000 110,000 170,000 87,000 880,000 48,000 11,000 13,000 10,000 20,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 J 23,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000	R20-SO-8 180,000 66,000 < 41,255 J 63,000 J 76,000 220,000 < 41,255 J 37,000 < 41,255 J 49,000 200,000 < 41,255 C 41,255	Average Conc 80,219 04,219 202,996 78,750 9,000 132,000 85,083 487,500 30,955 29,657 330,936 62,500 111,480 23,313 24,613	Maximum Cone 190,000 86,000 390,000 110,000 230,000 87,000 890,000 49,000 37,000 1,200,000 130,000 200,000 26,000 27,000	Std Dev 53,563 23,974 199,200 40,889 34,419 52,933 344,813 14,990 6,963 579,920 45,856 62,459 3,601 4,508	90% Confidence Interval Upper Limit 124,103 63,007 30,113 110,074 87,189 199,640 90,057 799,736 52,626 38,468 605,646 100,056 162,623 31,565 33,624	2 1, 2 1, 2 1, 2
Acensphthene Anthracers Benze(a)enthraces Benze((a)enthraces Benze((a)enthraces Benze(a)pyrene Carbazole Chysene Dibenze(a,h)enthracene Dibenze(uran 7,12 - Dimetry/benze(a)enthraces Fluorenthene Indene(1,2,3 cd pyrene 3 - Methylchotanthurne 2 - Methylchotysene	Semivolatile Org CAS No. 83329 120127 56533 NA 191242 50326 66748 218019 53703 132049 57976 206440 86737 193305	anios - Method R4-SO-01 < 61,875 380,000 J 110,000 230,000 < 123,750 700,000 < 61,875 < 61,875 J 43,000 < 61,875 < 61,875 < 61,875 < 61,875	82708 µg/kg R9-60-01 46,000 77,000 110,000 170,000 170,000 87,000 860,000 49,000 1,200,000 10,000 110,000 26,000 < 20,625	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000	R20-SC-8 160,000 66,000 41,25 J 60,000 J 67,000 J 07,000 < 41,25 J 37,000 < 41,25 J 49,000 200,000 < 41,25 C 4	Average Conc 80,219 94,219 202,999 78,750 9,000 65,083 467,500 90,956 9,957 330,636 62,500 111,460 23,313 22,813	Maximum Cone 190,000 86,000 390,000 110,000 230,000 87,000 89,000 49,000 1,200,000 130,000 20,000 27,000	Std Dev 53,963 23,974 199,200 40,889 34,419 52,933 22,935 344,613 14,695 6,963 579,620 45,156 62,456 3,601 4,508 221,560	90% Confidence Interval Upper Limit 124,103 63,607 380,113 110,074 87,189 189,640 90,057 789,736 52,626 38,468 605,646 100,056 162,523 31,565 33,624 563,663	1, 2 1, 2 1, 2 1, 2
Acensphthene Anthracene Benzo(a)anthracene Benzo(a)anthracene Benzo(a,h.)penylane Benzo(a,h.)penylane Carbazole Chysene Dibenzo(a,h.)enthracene Dibenzo(uran 7,12-Dimethylbenz(a)anthracene Fluoranthene Fluorantene Indeno(1,2,3-cd pyrene 3-Methylchotanthene 2-Methylchysene 1-Methylchysene	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 60748 218019 53703 132049 57676 206440 88737 193395 56495 3351324	anios - Method R4-90-01 < 81,875 < 61,875 390,000 J 110,000 J 90,000 < 123,750 700,000 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 060,000 J 140,000	182708 µg/kg R9-80-01 48,000 77,000 360,000 110,000 170,000 87,000 87,000 21,000 1,280,000 110,000 110,000 20,000 20,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000 180,000 570,000	R20-SC-8 160,000 64,000 41,255 J 65,000 J 76,000 220,000 41,255 J 37,000 441,255 J 49,000 441,255 C 41,255 41,255 230,000 2200,000 2200,000	Average Conc 80,219 64,219 202,960 78,750 59,000 132,000 65,083 447,500 90,967 330,030 62,500 111,460 23,313 24,813 362,500 800,000	Maximum Conc 190,000 86,000 390,000 110,000 230,000 87,000 49,000 37,000 1,200,000 200,000 27,000 26,000 27,000	Std Dev 53,863 23,874 199,200 40,889 34,119 82,933 22,1035 344,113 14,500 8,163 579,120 45,158 62,459 3,601 4,508 221,509	90% Confidence Interval Upper Limit 124,103 63,807 389,113 110,074 87,189 169,840 90,057 789,736 62,925 30,468 605,846 100,056 162,623 31,505 33,624 563,963 1,378,208	1, 2 1, 2 1, 2 1, 2
Acenaphthene Anthracens Genzoliuoranthene (total) Genzolgut, perpinne Benzolgut, perpinne Benzolgut, perpinne Carbazole Chysene Dibenz(a, h) enthracena Dibenz(a, h) enthracena Fluoranthene Fluoranthene Fluoranthene Fluoranthene 1-defnylchotanthrane 2-Methylchotanthrane 1-defnylnaphthelane 2-Methylnaphthelane 2-Methylnaphthelane	Semivolatile Org CAS No. 83329 120127 56853 NA 191242 50326 66746 218019 53703 132049 57976 208440 86737 193305 56495 3351824	anios - Method R4-SO-01 < 61,875 < 61,875 >360,000 J 110,000 < 123,750 700,000 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875	82708 µgkg R9-80-01 46,000 77,000 360,000 110,000 87,000 87,000 49,000 1,200,000 1,200,000 1,000 20,000 < 20,625 460,000 490,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 < 20,625 J 28,000 < 20,625 J 27,000 160,000 570,000	R20-SO-8 160,000 64,000 41,254 J 63,000 J 76,000 220,000 4 41,254 J 49,000 200,000 4 41,254 230,000 2,200,000 2,200,000 E 3,600,000	Awerage Conc 80,219 60,219 202,999 76,750 69,000 132,000 65,083 467,500 30,985 29,697 330,986 62,500 111,499 23,313 23,613 362,500 800,000 11,282,500	Maximum Cone 180,080 86,080 190,080 110,080 190,090 87,090 880,080 49,890 1,200,000 120,000 26,000 27,000 680,000 2,200,000 3,600,000	Std Dev 53,563 23,874 199,200 40,869 34,419 82,933 322,135 344,813 14,800 8,963 579,120 45,156 02,459 3,801 4,508 221,560 950,193 1,571,822	90% Confidence Interval Upper Limit 124,103 63,607 366,113 110,074 87,189 189,640 90,657 769,736 62,626 98,466 100,056 162,623 31,565 33,624 563,963 1,579,208 2,579,822	1, 2 1, 2 1, 2 1, 2
Acensphthene Anthracene Benzo(ach, perylane Benzo(ach, perylane Benzo(ach, perylane Benzo(ach, perylane Benzo(ach, perylane Carbacole Chysene Dibenz(a, n) enthracene Dibenz(a, n) enthracene Fluoranthene Fluoranthene Fluoranthene Indeno(1,2,3—cd pyrene 3—Methylichotanthene 1—Methylinophthelene 2—Methyliophthelene 2—Methyliphotanthene 2—Methyliphotal	Semivolatile Org CAS No. 89329 120127 56853 NA 191242 50328 66748 218019 53703 103249 57676 206440 86737 193365 56495 3051324 90120 91576	anios - Method R4-80-01 < 61,875 < 61,875 360,000 J 110,000 230,000 < 123,750 700,000 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 31,875 < 61,875 < 61,875 < 31,875 < 31,875	82708 µg/kg R9-80-01 46,000 77,000 110,000 110,000 170,000 87,000 21,000 130,000 110,000 130,000 48,000 20,000 48,000 20,000 480,000 40,000 20,000 40,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000 180,000 570,000 < 20,625	R20-SO-8 180,000 66,000 4 11,255 J 60,000 J 76,000 220,000 < 41,255 J 37,000 < 41,255 J 49,000 200,000 < 41,255 C 41,255	Average Conc 80,219 94,219 202,999 78,750 9,000 85,083 487,500 9,855 2,9,697 330,636 42,500 111,469 23,313 22,813 382,500 1,292,500	Maximum Cone 190,000 86,000 390,000 110,000 130,000 87,000 860,000 49,000 1,200,000 130,000 200,000 25,000 27,000 680,000 2,200,000 3,600,000 32,000	Std Dev 53,563 23,974 199,200 40,889 34,419 82,933 322,935 344,913 14,900 8,963 579,920 45,958 62,459 3,601 4,508 221,500 950,193 1,571,822 6,567	90% Confidence Interval Upper Limit 124,103 63,007 300,113 110,074 87,189 189,640 90,057 709,735 52,626 38,468 605,644 100,056 162,623 31,505 33,624 563,963 1,379,206 2,579,826	1, 2 1, 2 1, 2 1, 2
Acensphthene Anthracene Benz(a)anthracene Benzo(a)anthracene Benzo(a,h.)perylane Benzo(a)pyrene Carbazole Chrysene Dibenzo(arthracene Dibenzo(arthracene Dibenzo(arthracene Fluoranthene Fluoranthene Indeno(1,2,3 cd pyrene 3 Melthylanthracene 1 Melthylanthracene 2 Melthylanthracene 3 Melthylanthracene	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 66748 218019 53703 132640 57676 206440 86737 193395 56495 3351324 90120 91576 95487	anios - Method R4-90-01 < 81,875 < 61,875 390,000 J 110,000 J 90,000 < 123,750 700,000 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 060,000 J 140,000 J 140,000 J 32,000 J 32,000	182708 µg/kg R9-80-01 48,000 77,000 300,000 110,000 170,000 87,000 49,000 21,000 130,000 110,000 100,000 22,000 20,000 40,000 28,000 28,000 28,000 280,000 280,000 280,000 280,000 280,000 280,000 280,000 280,000 280,000 280,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000 169,000 570,000 900,000 < 20,625 < 20,625 < 20,625	R20-SO-8 160,000 64,000 41,255 J 63,000 J 76,000 220,000 41,255 J 37,000 441,255 J 49,000 41,255	Average Conc 80.219 64.219 202.986 78.750 65,083 467,500 90,987 30,036 62,500 111,469 23,313 32,813 362,500 11,202,500 12,417 27,417	Maximum Conc 190,000 86,000 390,000 110,000 230,000 87,000 49,000 37,000 1,200,000 200,000 27,000 27,000 28,000 27,000 3,600,000 3,600,000 41,000	Std Dev 53,963 29,974 199,200 40,889 34,419 82,933 22,935 344,613 14,600 8,963 579,620 45,168 02,459 3,601 4,506 950,193 1,571,622 0,507 11,764	90% Confidence Interval Upper Limit 124,103 63,807 389,113 110,074 67,189 189,840 90,057 789,736 62,926 38,468 605,846 100,056 162,623 31,505 33,624 563,963 1,578,206 2,579,622 31,506	1, 2 1, 2 1, 2 1, 2
Acensphthene Anthracens Benz(a)anthraces Benzo(a).Nperylane Benzo(a)pyrene Carbazole Chysene Dibenzoluren J. 12 – Dimethylbenz(a)anthracens Fluorene Indeno(1,2,3 – cd[pyrene 3 – Methylchotanthrane 2 – Methylnsphthelene 3/4 – Methylphenol 3/4 – Methylphenol 3/4 – Methylphenol 3/4 – Methylphenol 3/5 – Methylphenol 3/6 – Methylphenol 3/6 – Methylphenol 3/7 – Methylphenol	Semivolatile Org CAS No. 83329 120127 56553 NA 191242 50326 66748 218019 53703 132649 57976 206440 86737 193305 56495 3351324 90120 91576 95447 NA	anios - Method R4-80-01 < 61,875 < 61,875 390,000 J 110,000 < 123,750 700,000 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 61,875 < 11,870 J 140,000 J 140,000 J 140,000 J 32,000 J 41,000 J 42,000 J 42,000	# 82708 μg/kg R9 - 80 - 01 46,000 360,000 110,000 87,000 87,000 49,000 1,290,000 1,290,000 1,290,000 26,000 2 0,825 480,000 2 0,825 480,000 2 0,825 480,000 2 0,825 480,000 2 0,825 8 0,000 2 0,825 8 0,000 2 0,825 8 0,000 2 0,825 8 0,000 2 0,825 8 0,000 2 0,825 8 0,000 2 0,825 8 0,000	R18-SO-01 53,000 J 32,000 < 20,625 J 27,000 52,000 < 41,250 170,000 < 20,625 J 31,000 < 20,625 J 28,000 74,000 < 20,625 J 27,000 180,000 570,000 900,000 < 20,625 180,000	R20-SO-8 160,000 66,000 66,000 66,000 176,000 J 63,000 J 76,000 220,000 < 41,256 J 49,000 20,000 (41,256 230,000 2,200,000 E 3,600,000 < 41,256 < 41,256 3600,000 < 41,256 < 41,256 < 41,256 3600,000 < 41,256 < 41,256 < 41,256 < 41,256 < 41,256 < 41,256 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 < 41,250 <	Awerage Conc 80,219 60,219 202,999 78,750 85,083 487,500 30,936 29,987 330,936 62,500 111,499 23,913 24,813 362,500 60,000 1,292,500 24,417 27,417 172,500	Maximum Cone 190,000 86,000 390,000 110,000 100,000 87,000 890,000 1,200,000 1,200,000 200,000 26,000 27,000 680,000 38,000,000 32,000 41,000 31,000 32,000	Std Dev 53,563 23,874 199,200 40,869 34,419 82,933 322,135 344,813 14,800 8,983 579,820 45,156 3,801 4,508 221,566 550,193 1,571,622 6,567 11,764 134,862	90% Confidence Interval Upper Limit 124,103 63,607 366,113 110,074 87,189 169,640 90,067 769,736 62,626 98,468 905,646 100,056 162,823 31,565 33,624 563,663 1,375,206 2,579,822 31,506 40,226 282,952 282,952	1, 2 1, 2 1, 2 1, 2
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- Comments:

 1 Detection limits greater than the highest detected concentration are excluded from the calculations.

 2 Upper Limit exceech the maximum concentration.

Notes:

- A hastyle also detected in the associated method bents.

 I compound's comparation is estimated. Man a specified date indicate this presence of a comparation to see the Identification or other for which the result is less than the laboratory delection limit but greate than 2410.

 NO Not Described.

 NA Not Applicable.

3.2 CATALYTIC CRACKING

3.2.1 Process Description

Catalytic cracking is a process for the conversion of straight-run atmospheric gas oil, vacuum gas oils, and heavy stocks recovered from other operations into high-octane gasoline, light fuel oils and olefin-rich light gases. Available catalytic cracking technologies include fluid catalytic cracking, residual catalytic cracking, and Thermofor catalytic cracking. Because catalytic cracking increases the gasoline yield from crude oil, over 60% of the refineries in the United States have at least one of these units.

Fluid catalytic cracking (FCC) is by far the most widely used by industry (95% of all catalytic cracking units in the U.S.) and will be the primary focus of this discussion. FCC capacities range from 2,400 to 120,000 barrels per stream day. The silica-alumina catalyst has a small particle size (average size

FCC is an effective process for increasing the yield of gasoline from crude oil

51 to $65 \mu m$) and moves through the reactor as a fluid. Figure 3-2-1 provides a generic process flow diagram for fluid catalytic cracking. In the FCC process, light and heavy vacuum gas oil and a mixture of middle to heavy petroleum fractions are preheated and then contacted with hot FCC catalyst. The reactor's temperature is 850° to 950° F and its pressure is between 12 to 50 psig (McKetta, 1992). The oil vaporizes and forms a fluidized mixture with the catalyst particles and is literally blown around the large reactor. The oil cracks forming lighter hydrocarbons as it rises through the reactor. The oil and catalyst are separated by cyclones at the top of the reactor, and the cracked products are recovered in the main fractionator.

The fractionator separates the cracked hydrocarbons into products. The products are generally light gases (butanes and lighter), cat cracked gasoline, light and heavy gas oils, and CSO. See Section 3.1.3 for further description of CSO generation.

During the cracking process, coke deposits on the catalyst and renders it inactive. The coke is burned off the catalyst in the regenerator. The regenerator operates at a higher temperature (1100° to 1300°F) than the reactor which allows the coke to be burned off. The bulk of the regenerated catalyst is recycled back to the reactor. However, because the catalyst loses some activity over time due to deposition of metals (e.g., vanadium and nickel) and neutralization of active acid sites (e.g., sodium and sulfate), a slip stream of catalyst is removed after regeneration and replaced with fresh catalyst. This slip stream of catalyst, typically 1% of the catalyst inventory, is called equilibrium catalyst, a residual of concern. Catalyst losses can also be attributed to fines entrained in the regenerator off-gas or flue gas and in the CSO.

Depending on local air pollution control standards, catalyst fines from the regenerator flue gas may be removed in an electrostatic precipitator or a wet gas scrubber, or can be sent to the stack. The collected catalyst fines are a residual of concern.

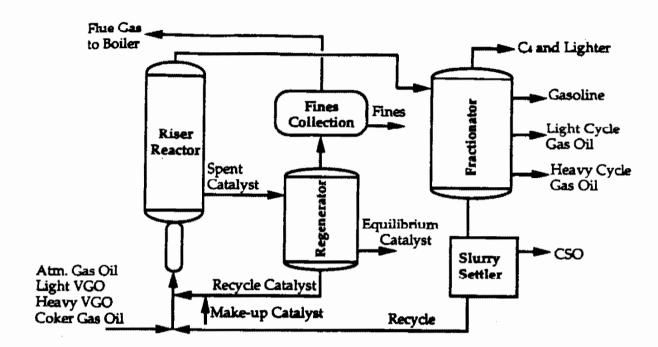


Figure 3.2.1. Fluid Catalytic Cracking Process Flow Diagram

As mentioned above, other process variations include residual catalytic cracking (RCC) and Thermofor catalytic cracking (TCC). The RCC is basically the same configuration as the FCC unit varying only in the feed. The feed is a mixture of fractions from the vacuum unit. This heavier grade feed has a higher metals content which causes the catalyst to lose its activity more quickly. Larger reactors are used to compensate for the metals loading.

In 1992, four refineries had TCC units with capacities ranging from 4,500 to 17,000 barrels per stream day. The TCC unit is a moving-bed cracking unit. In the moving bed process, the catalyst (a zeolitic catalyst) is pelletized into about 1/8 inch diameter beads. These beads flow by gravity from the top of the unit down through the reactor which operates at about 10 psig and 850° to 925°F (McKetta, 1992). The oil is injected at the top of the reactor and flows concurrently with the bead catalyst to the bottom of the reactor where product vapors are collected in underflow weir channels and are ducted to the fractionator. The catalyst then flows down to the regenerator or kiln. In the regenerator, air is introduced and the temperature is raised to about 1150° to 1250°F to burn off the coke which formed on the catalyst during the cracking process. Bucket elevators or pneumatic lifts are used to carry the catalyst from the bottom of the regenerator back to the top of the reactor.

3.2.2 FCC Equilibrium Catalyst - Residual 4

3.2.2.1 <u>Description</u>

As discussed above, heavy polyaromatic coke and carbon deposit on the silica-alumina catalyst during the cracking process causing it to lose its activity and become spent. These deposits are removed by burning the coked catalyst in the regenerator to reestablish activity prior to its recycle to the reactor. Metals, such as vanadium and nickel, from the crude oil also deposit on the catalyst, reducing activity. To control metal levels on the catalyst, equilibrium catalyst is drawn from the regenerator frequently (about once a week) and replaced with fresh catalyst.

Factors contributing to the degradation of the catalyst include high temperature, impurities in the fresh catalyst, impurities in the hydrocarbon feed, and time. Residual impurities in the fresh manufactured catalyst are principally sodium and sulfate. Impurities from the feed are sodium, nickel, vanadium, iron and copper. Sodium acts to neutralize active acid sites and aids in matrix degradation. Deposited metals effectively act as catalyst poisons. Metals levels on equilibrium catalyst reflect the metals content of the feeds being processed; typical ranges are 200 to 1,200 ppm vanadium, 150 to 500 ppm nickel, and 5 to 45 ppm copper. Sodium levels are in the range of 0.25 to 0.8 wt% (as NaO₂) (McKetta, 1992).

The equilibrium catalyst from the regenerator is placed in a catalyst hopper where it is cooled and stored prior to final management. Equilibrium catalyst from one refinery's FCC may be used at another refinery where the FCC unit requires a catalyst with a lower activity level.

Although this is a high-volume stream, less than 3 percent of its volume is currently managed as hazardous. Some refineries manage their FCC catalyst and fines in onsite dedicated catalyst monofills.

The catalyst in the TCC unit is a zeolitic bead-type catalyst that is removed and replaced only during turnaround. The catalyst makeup, frequency of generation, and process design are all different from the FCC process. In addition, the TCC process is much less common than the FCC and RCC processes. Therefore, the catalyst in the TCC unit was not considered to be within the scope of this study.

3.2.2.2 Generation and Management

The §3007 questionnaire responses indicated 124,061 MT of equilibrium catalyst were generated in 1992. Residuals were assigned to be "FCC catalyst" if they were assigned a residual identification code of "spent solid catalyst" and were generated from a process identified as an FCC unit. This corresponds to residual code 03-A in Section VII.2 of the questionnaire and process code 04-A in Section IV-1.C of the questionnaire. Except for the RCC, other catalytic cracking units were omitted from this designation. In this industry

study, equilibrium catalyst was the largest volume of spent catalyst examined. Table 3.2.1 provides a description of the total quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.2.1. Generation Statistics for FCC Equilibrium Catalyst							
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)		
Disposal offsite Subtitle D landfill	35	0	23,326.5	666	1,575		
Disposal onsite Subtitle D landfill	11	0	2,894	263	1,125		
Disposal offsite Subtitle C landfill	3	0	155	52	140		
Disposal onsite Subtitle C landfill	4	0	3,982	995	3,072		
Offsite land treatment	3	0	713	238	446		
Onsite land treatment	2	0	559.6	280	512		
Onsite reuse	8	2	4,051	506	2,388		
Other reuse/cement plant ²	40	0	55,901	1,397.5	4,811		
Transfer to offsite entity	5	0	1,740	348	1,196		
Transfer metal catalyst for reclamation	4	0	5,922	1480	2,627.6		
Transfer to another petroleum refinery	62	1	24,817	400	890		
Total FCC catalyst	178	3	124,061	697	1,575		

¹ Offsite entities include alumina manufacturer and steel industry.

Plausible management scenarios were chosen by EPA on which to perform risk assessment modeling. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.2.1 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment.

The selected management practice is:

An onsite monofill will be used as the worst-case plausible mismanagement.

Because the volumes and generation rates are sufficient, onsite monofills are

² Includes quantities reported to be transferred for ingredient in products placed on land.

used by industry and plausible large volumes can go into a monofill.

Refineries reported 26,221 MT (about 21 percent) of catalyst were disposed in Subtitle D landfills.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.2.2. The management unit characterization data were provided in the §3007 survey. Table 3.2.3 provides a summary of the management unit characteristics and aquifer information.

The Agency did not model storage of FCC catalysts and fines. FCC catalysts and fines are typically managed in pneumatic containers and hoppers prior to final management due to their particle sizes and the large volumes handled. These storage vessels are designed to minimize dust emissions and control losses. The Agency, however, did model potential air releases in the modeled monofill scenario for FCC residuals. Thus, interim storage was not modeled because of the nature of the storage vessels typically used and the consideration of air pathway releases during long-term final management.

3.2.2.3 Characterization

The category of "catalyst and fines from catalytic cracking" as defined in the EDF consent decree includes the subcategories of "equilibrium catalyst" and "fines". These subcategories were chosen because these two residuals are generated at different points in the process and because the Agency hypothesized that the different particle sizes of catalyst and fines might result in different risk results. See Section 3.2.3 for a description of fines from catalytic cracking.

Two sources of residual characterization were developed during the industry study:

- Table 3.2.4 summarizes the physical properties of the catalyst as reported in Section VII.A of the §3007 survey.
- The two equilibrium catalyst samples were collected and analyzed by EPA. The samples were collected from the catalyst hoppers during normal operating conditions. Table 3.2.5 provides the location and description of the samples.

These samples are believed to be representative because they were taken from units accepting various types of crude feeds neither of which were pretreated (hydrotreated). Table 3.2.6 provides a summary of the characterization data. Only constituents detected in at least one sample are shown in this table. As shown in the data, none of the FCC catalyst samples exhibited the toxicity characteristic even though heavy metals are present. High aluminum concentrations can be attributed to the silica-alumina catalyst. Because of the severe operating conditions of the unit, the spent catalyst has a very low organic content.

Table 3.2.2. Selection of Risk Assessment Modeling Scenario: FCC Equilibrium Catalyst				
Waste	Basis for Consideration in Risk Assessment			
Disposal offsite Subtitle D landfill	Monofill scenario was assumed to pose greatest potential risk because the residual is not mixed or diluted with other materials in an unlined monofill.			
Disposal onsite Subtitle D landfill	Modeled as a monofill as worst case bounding estimate.			
Disposal offsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control			
Disposal onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control			
Offsite land treatment	Monofill scenario was assumed to pose greatest potential risk			
Onsite land treatment	Monofill scenario was assumed to pose greatest potential risk			
Onsite reuse	Excluded management practice			
Other reuse/cement plant	Not modeled. Assumed small percentage of feed to cement kiln with very low levels of constituents of concern. Cement would tend to immobilize any trace metals.			
Transfer to offsite entity!	Not modeled, assumed to be used as a raw material substitute, excluded management practice			
Transfer metal catalyst for reclamation	Sent to exempt recycling			
Transfer to another petroleum refinery	Not modeled, excluded management practice			
Other storage	Not modeled, not final management			

Offsite entities include alumina manufacturer and steel industry.

Table 3.2.3. Management Practices Targeted for Risk Assessment									
FCC Equilibrium Catalyst									
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)		
Onsite Subtitle D Landfills		11	0	2,894.2		36.5	1,125		
Offsite Subtitle D Landfills		35	0	23,326.5		235	1,575		
Onsite and Offsite			0	26,221	_	197	1,693		
Subtitle D Landfills		Onsite Landfill Characteristics							
	Surface A	rea (acres)			1.25	5.9	33		
	Remaining	Capacity	(1 000 cu.yd.)		3.025	24.45	6,500		
	Percent Re	maining C	apacity		0.48	5	34.5		
	Total Cape	city (1000	cu.yd.)	12.1	75.325	10,498			
	Number o	f Strata in	Completed Unit	Q	3	8,030			
	Depth Bel	ow Grade (ft)	0.5	6	32.5			
	Height Ah	ove Grade	(ft)	0	7	72			
	# of Land	# of Landfills: 10							
	Aquifer Information								
	Depth to A	Aquifer (ft)	V COMPANIE CONTRACTOR	14	34.5	232.5			
	Distance to	Private V	/ell (ft)	1,000	8,970	37,500			
	Population	Using Pri	vate Well	1	1	1			
	Distance to	Public W	eil (ft)	5,000	9,850	58,000			
	Population	Using Put	olic Well	1,500	1,750	2,000			
·	# of Aquifers: 10								
	Source: Unreporte Uppermos Lowermos Combinati	t a on	Public 4 4 7 7 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7	4 2 3 -					
	Current or potential source of drinking water (4) Not considered a potential source of drinking water (6)								

The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

Table 3.2.4. FCC Equilibrium Catalyst Physical Properties							
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %		
рН	58	85	4.3	5.9	8		
Reactive CN, ppm	42	101	0	19.2	10		
Reactive S, ppm	45	98	0	19.1	67.5		
Flash Point, °C	41	102	60	106.3	140		
Oil and Grease, vol%	36	107	0	0.21	1		
Total Organic Carbon, vol %	36	107	0	0.2	1		
Specific Gravity	66	77	0.85	1.56	2.25		
BTU Content, BTU/lb	15	128	0	776.7	1,000		
Aqueous Liquid, %	84	59	0	0.24	0		
Organic Liquid, %	83	60	0	0.05	0		
Solid, %	126	17	100	99.4	100		
Particle > 60 mm, %	48	95	0	0.28	0		
Particle 1-60 mm, %	48	95	0	8.6	4.5		
Particle 100 μm-1 mm, %	55	88	0	30.4	100		
Particle 10-100 μm, %	71	72	20	71.3	100		
Particle < 10 μm, %	61	82	0	6.8	15		
Mcan Particle diameter, microns	60	81	50	74	84		

Table 3.2.5. FCC Equilibrium Catalyst Record Sampling Locations						
Sample Number	Location	Description				
R4-FC-01	Little America, Casper, WY	FCC equilibrium catalyst from hopper				
R6-FC-01	Sheil, Norco, LA	FCC equilibrium catalyst off the regenerator				

3.2.2.4 Source Reduction

Source reduction techniques are very difficult to formulate due to the limited number of inputs to the system. The FCC unit inputs are heavy hydrocarbons and catalyst, neither of which can be reduced, substituted or eliminated. However, by employing process efficiency modifications and/or reuse procedures, spent catalyst can be diverted from landfilling.

One refinery reported in the §3007 survey that caked FCC catalyst generated during turnaround was eliminated due to equipment and process changes.

A Peruvian FCC unit's operations were improved by increasing the regenerator's catalyst level. This increase resulted in lower stack losses, an improved temperature profile, increased catalyst activity and a lower catalyst consumption rate. (HC Processing, 11/93)

Peruvian refiner saves over \$131,000 per year in catalyst purchases

Hydrotreating FCC feed helps to remove metals and sulfur compounds from the feed. This can extend the life of the FCC equilibrium catalyst, which decreases the volume of spent catalyst generated.

One common example of reuse is the use of equilibrium catalyst from one refinery's FCC at another refinery where the FCC unit requires catalyst with a lower activity level. In 1992, 50,000 MT of spent catalyst were used as a feedstock in the production of cement.

Table 3.2.6. FCC Equilibrium Catalyst Characterization

							•	90% Confidence			
	Volatile Organica							Interval			
	CAS Na.	R4-			Average Conc	Meximum Conc	Std Dev	Upper Limit	Comments		
Ethylbenzene	100414		6,400		3,465	0,400	4,122	12,457	2		
n-Propylbenzene	103651		2,200		1,385	5.500	1,150	3,894	2		
Toluene	108883		17,000	< 570	8,785	17,000	11,816	34,071	2		
1,2,4-Trimethy/benzene	₽5836		13,000	1,300	7,150	13,000	8,273	25,156	2		
3,5-Trimethy/benzene	108678		5,100	< 570	2,635	5,100	3,200	9,807	2		
o-Xylene	95476		11,000	< 570	5,785	11,000	7,375	21,837	2		
m,p - Xylenes	108363 / 108423		35,000	< 570	17,765	35,000	24,340	70,773	2		
Mathyl athyl kalone	78933		1,400	< 570	985	1,400	567	2,262	2		
Naphihalane	91203	≺	625	3,000	1,613	3,000	1,679	5,468	2		
	}						1	90% Confidence			
	TCLP Volatile Organics - Methods 1311 and 8260A µg/L					nierval					
	CAS No.	R4 -	-FC-01	R6-FC-01	Avarage Conc	Maximum Conc	Std Dev	Upper Lines	Commenta		
Acelone	87641		100	< 50	75	100	35	152	2		
Toluene	108883	В	160			160	78	274	2		
m,p-Xylenes	106363 / 106423	8	150	< 50	100	150	71	254	2		
Mathyl athyl katona	78933		150	< 50	100	150	71	254	2		
								90% Confidence			
Semivolatile Organica — Method 8270B µg/kg						In					
	CAS No.		-FC-01	R6-FC-01	Average Conc	Maximum Conc	Std Dev	Upper Lines	Comments		
1 - Methylnaphihalene	20120		510		338	510	244	868	2		
2 - Mathythaphthalene	P1578	_	870		518	870	490	1.602	2		
Hapithelene	B1203		670		418	670	357	1,195	2		
Di – n – butyl phtheiste	84742	<	105	1,000	583	1,000	590	1,606	5		
	90% Confidence										
	TCLP Semivolatile Organics - Mathods 1311 and 8270B µg/L						Interval				
	CAS No.		-FC-01			Maximum Conc	Std Dev	Upper Limit	Comments		
Bis (2 - sthylhexyl) phihalate	117817		23				al	21	2		
DIS \$2 - ensymments produce		00	1.51	, ,,		. 201	-1	,	_		
	Total Malais - Mathoda 6010, 7050, 7421, 7470, 7471, and 7641 mg/kg					,	90% Confidence Interval				
	CAS No. R4-FC-01 R6-FC-01 Average Conc Meximum Conc				Std Day	Upper Lime	Commente				
et	7420005		10.000.01	31,000,0	60.000.0	0,000,01	41,012.2	149,202.0	2		
Aluminum	7440362		1.0	2.5	1.8	2.5	1.1	4.1	2		
Are enic	7440393	`		< 20.0	1	190,0	120.2	300.0	2		
Barium	7440417		2.7	1.7	2.2	2.7	0.7	3.7	2		
Beryttium	7440702		1.700.0	< 500.0		1,700.0	848.5	2,940.8	2		
Calcium	7440473		17.0	4.3		17.0	9.2	30.5	2		
Chromium				18.0		18.0	9.2	31.5	2		
Cobalt	7440484 7440508	<	5.0 19.0	13.0	15.0	10.0	4.2	25.2	2		
Copper	7440508 7439808		4,800.0	1,000.0	2,000.0	4,800.0	2,587.0	8,748 2	2		
tion	7439698		′	11.0	25.5	42.0	21.9	74.2	2		
Lead 	7439965		42.0 32.0		1	32.0	21.0	63.7	2		
Manganese	7440020		330.0	8 1.0		330.0	159.0	578.3	2		
Nickel Cartings	7440235		9.600.0	1.900.0	,	9,600,0	5,586.1	18,009,1	2		
Sodium	7440822		1,200.0	720.0		1,200,0	330.4	1,698.7	2		
Vanadium	7440666		68.0	2.3	,	68.0	41.5	129 0	2		
2inc	1 440000	1	40.0	₽.3	1 40.1	, 04.01	71.0		•		

FCC EQUILIERRUM CATALYST

						90% Contidence	
TCLP Metals - N	Aethode 1311, 6	010, 7060, 7421	i, 7470, 7471, an	d 7841 mg/L		interval	
CAS No.	R4-FC-01	R6-FC-01	Average Conc	Meximum Conc	Std Day	Upper Limit	Comments
7440360	< 0.30	2.00	1.15	2.00	1.20	3.77	2
7439896	< 0.50	1.30	0.90	1.30	0.57	2.13	2
7440020	< 0.20	1.10	D. 6 5	1.10	0.54	2.04	2
7440622	9.50	0.85	5.18	9.50	0.12	13.49	2
7440668	0.25	< 0.10	0.18	0.25	0.11	0.41	2

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Upper Limit exceeds the maximum concentration.

Notes

- B Analyte also detected in the easociated method blank.
- J Compound's concentration is estimated. Mess spectral data indicate the presence of a compound that meats the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- NO Not Delected.
- NA Not Applicable.

Antimony Iron Nickel Vanadium Zinc

3.2.3 FCC Catalyst Fines - Residual 5

3.2.3.1 <u>Description</u>

Fluid catalytic cracking is the only catalytic cracking process that generates a residual of catalyst fines (RCCs also produce catalysts fines, however the RCC process is identical to the FCC process only processing heavier feeds). In the FCC process, the flue gas off the regenerator will likely have any of a number of optional units associated with it for air pollution control. The flue gas is composed of catalyst fines, nitrogen from the air used for combustion, the products of coke combustion (the oxides of carbon, sulfur, nitrogen, and water vapor), and trace quantities of other compounds (Meyers, 1986). Flue gas is directed through cyclone separators to minimize catalyst entrainment prior to discharge from the regenerator. The flue gas exits the regenerator at high temperature, approximately 700° to 780°C, and at pressure of about 30 psig. Depending on local air pollution control standards, the remaining catalyst fines may be removed in an electrostatic precipitator or a wet gas scrubber, or can be sent directly to the stack.

In electrostatic precipitators, catalyst fines are collected by using the mutual attraction between particles of one electrical charge and a collecting electrode of opposite polarity. Using high-voltage electrodes, the flue gas is ionized and the catalyst fines in the gas become charged. The charged fines then migrate to the plate electrodes, where fines collection occurs. The deposited fines are usually removed from the electrodes by rapping or vibration. With relatively weak electrical attraction between the fines adjacent to the plate and the plate itself, the fines fall by gravity into a collection hopper (Wark and Warner, 1981).

In wet gas scrubber systems, the flue gas and any entrained catalyst are scrubbed using a circulating water system. Caustic is added to the water to neutralize the SO₂ and NH₃ scrubbed out of the flue gas. Some refineries use spent caustic from liquid treating operations in their FCC off-gas scrubbers. The catalyst fines settle out of the water in scrubber ponds or are sent to a dewatering system. The catalyst is removed from the ponds as needed.

Although this is a high-volume stream, less than 2 percent of its volume is currently managed as hazardous. Some refineries manage their FCC catalyst and fines in an onsite dedicated catalyst monofill.

3.2.3.2 Generation and Management

The §3007 questionnaire responses indicated that 67,816 MT of catalyst fines were generated in 1992. Residuals were assigned to be "FCC fines" if they were assigned a residual identification code of "solid catalyst fines" and were generated from a process identified as an FCC unit. This corresponds to residual code 03-B in Section VII.2 of the questionnaire and process code 04-A in Section IV-1.C of the questionnaire. Except for the RCC, other catalytic cracking units were omitted from this designation. Table 3.2.7

provides a description of the total quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.2.7. Generation Statistics for FCC Catalyst Fines									
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)				
Disposal offsite Subtitle D landfill	44	1	32,819	746	1,250				
Disposal onsite Subtitle D landfill	11	0	8,501	773	1,718				
Disposal offsite Subtitle C landfill	4	0	763	190	550				
Disposal onsite Subtitle C landfill	2	0	11.4	5.7	6.4				
Offsite land treatment	2	0	419	210	416				
Disposal/storage in surface impoundments ¹	4	0	7,096	1,774	5,309				
Other disposal onsite/cap for landfarm	2	0	2,930	1465	1,630				
Other disposal onsite/fill material	1	0	1,633	1,633	1,633				
Other disposal onsite/vent to atmosphere	8	1	1,640	205	421.4				
Recovery onsite in FCC	1	0	250	250	250				
Other reuse/cement plant	19	0	10,048	529	1,460				
Transfer for use in products placed on the land	2	0	1352	676	698				
Transfer to another petroleum refinery	1	0	91	91	91				
Settling	2	0	263	131.5	263				
Total FCC fines	103	5	67,816	658	1,627				

¹ Five facilities with 6 surface impoundments were reported in the §3007 survey (for all generating years). Two are permitted as SWMUs, five are used for interim or final management of scrubber fines.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.2.7 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment.

The selected management practices are:

- An onsite monofill will be used as the worst-case plausible mismanagement.
 Because the volumes and generation rates are sufficient, onsite monofills are
 used by industry and plausible large volumes can go into a monofill.
 Refineries reported 41,320 MT (about 61 percent) of catalyst fines were
 disposed in Subtitle D landfills.
- While it appears to be a relative rare practice, the Agency also modeled disposal in surface impoundments to confirm that the scenario was not of concern.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.2.8.

The Agency did not model storage of FCC catalysts and fines. FCC catalysts and fines are typically managed in pneumatic containers and hoppers prior to final management due to their particle sizes and the large volumes handled. These storage vessels are designed to minimize dust emissions and control losses. The Agency, however, did model potential air releases in the modeled monofill scenario for FCC residuals. Thus, interim storage was not modeled because of the nature of the storage vessels typically used and the consideration of air pathway releases during long-term final management.

Management unit characteristics were reported in the §3007 questionnaire. Table 3.2.9 provides the management unit information for the FCC fines. Table 3.2.10 provides the management unit information for the FCC catalyst and fines combined.

Table 3.2.8. Selection of Risk As	sessment Modeling Scenario: FCC Catalyst Fines					
Management	Basis for Consideration in Risk Assessment					
Disposal offsite Subtitle D landfill	Not modeled, monofill scenario was assumed to pose greatest potential risk because the residual is not mixed with or diluted with other materials in an unlined monofill					
Disposal onsite Subtitle D landfill	Modeled as a monofill					
Disposal offsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control					
Disposal onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control					
Offsite land treatment	Not modeled, monofill scenario was assumed to pose greatest potential risk					
Disposal/storage in surface impoundments	Modeled					
Other disposal onsite ¹	Covered by landfill scenario					
Recovery onsite in FCC	Not modeled, assumed closed loop recycling					
Other reuse/coment plant	Not modeled, assumed small percentage of feed to cement kiln with very low levels of constituents of concern. Cement would tend to immobilize any trace metals present.					
Transfer for use in products placed on the land	Not modeled, assumed to be used in coment manufacture, see above					
Transfer to another petroleum refinery	Not modeled, exempt management practice					
Settling	Not modeled, not a final management practice					

¹ Other onsite disposal includes cap for landfarm, fill material, and vent to atmosphere.

Table	3.2.9. M	lanagen	ent Practices	Targeted	for Risk A	Assessment			
FCC Catalyst Fines									
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)			
Onsite Subtitle D Landfills	Allectroster	11	0	8,501.2		332	1,718.2		
Offsite Subtitle D Landfills		44	1	32,819.1		331	1,250		
Onsite and Offsite	40	55	1	41,320		414	2,753.6		
Subtitle D Landfills			Onsite	Landfill Char	acteristics				
	Surface A	rea (acres)			1	7	50		
	Remaining	Capacity	(1000 cu.yd.)		3.63	24.45	8,900		
	Percent Re	maining C	apacity		0.5	5	2.5		
	Total Cape	acity (1000	cu.yd.)		15	75.325	10,200		
	Number o	f Strata in	Completed Unit		0	1	400		
	Depth Bel	ow Grade	(ft)		1	5	15		
	Height Ab	ove Grade	(ft)		o	7	25		
	# of Land	fills: 11							
				Aquifer Inform	ation				
	Depth to	Aquifer (ft)			7	29.5	207		
	Distance to	Private V	Vell (ft)		5,000	8,985	26,800		
	Population	Using Pri	vate Well		3	3	3		
	Distance to	Public W	'ell (ft)		5,000	13,200	58,000		
	Population	Using Pri	vate Well		250	1,750	2,000		
	# of Aquit	ers: 10							
	Uppermos								
	0	urrent or p	permost Aquifer potential source of red a potential source						

¹ The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

Table 3.2.10. Management Practices Targeted for Risk Assessment										
FCC Catalyst and Fines										
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)				
Onsite Subtitle D Landfills ²	11	22	0	112,215	-	412	5,662			
Offsite Subtitle D Landfills ²	35	79	1	56,146	A-1000	605	3,507			
Onsite and Offsite	46	101	1	67,541		602.5	5,662			
Subtitle D Landfills ^{1,2}			Onsite	Landfill Char	acteristics					
	Surface A	rea (acres)			1	7.13	50			
	Remaining	g Capacity	(1000 cu.yd.)		3	24.5	9,100			
	Percent R	omaining C	apacity		0.5	5	44			
	Total Cap	acity (1000	cu.yd.)		15	78.2	10,498			
	Number o	f Strata in	Completed Unit		0	3	400			
	Depth Bel	ow Grade	(ft)		Ο.	5	15			
	Height Ab	ove Grade	(A)		0	7.5	72			
	# of Land	fills: 16								
				Aquifer Inform	ation					
	Depth to	Aquifer (ft)			12	34.5	200			
	Distance t	o Private V	Vell (ft)		1,000	8,970	26,800			
	Population	Using Pri	vate Well		1	2	3			
	Distance t	o Public W	'ell (fl)		5,000	10,100	58,000			
	Population	u Using Pri	vate Well		250	1,750	2,000			
	# of Aqui	fers: 14								
	Uppermos	Source: Public Private Unreported 7 8 Uppermost 2 4								
	Lowermost 5 2 Classification of Uppermost Aquifer Current or potential source of drinking water (5) Not considered a potential source of drinking water (9)									

The number of landfills characterized in Table 3.2.10 is greater than indicated in Tables 3.2.1 and 3.2.7 which focuses only on volumes generated in 1992. Table 3.2.10 incorporates data from all landfills receiving catalyst and fines in any year reported in the §3007 survey.

The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

3.2.3.3 Characterization

As discussed above, the category of "catalyst and fines from catalytic cracking" as defined in the EDF consent decree includes the subcategories of "equilibrium catalyst" and "fines". These subcategories were chosen because these two residuals are generated at different points in the process and because the Agency hypothesized that the different particle sizes of catalyst and fines might result in different risk results. See Section 3.2.2 for a description of catalyst from catalytic cracking. The subcategory "fines" was further divided based on how the residual fines are collected (e.g., wet or dry scrubber systems).

Two sources of residual characterization were developed during the industry study:

- Table 3.2.11 summarizes the physical properties of the catalyst as reported in Section VII.A of the §3007 survey.
- Four catalyst fines samples were collected and analyzed by EPA. Two "dry" samples of the catalyst fines were collected from the fines storage bins at the electrostatic precipitator. Two samples of fines were collected from the wet scrubbers: one was dredged from the fines storage pond, and one was collected after the fines had been dewatered. Table 3.2.12 provides the location and description of the collected samples.

As with FCC catalyst, there is little variation in feedstocks, catalyst type, and regeneration practices across the industry and these samples are believed to be representative. Table 3.2.13 provides a summary of the characterization data collected under this sampling effort. Only constituents detected in at least one sample are shown in this table. As presented in the data, none of the FCC fines samples collected exhibited the toxicity characteristic even though heavy metals are present. High aluminum concentrations can be attributed to the silica-alumina make up of the catalyst. Because the units operate at severe operating condition, the spent catalyst fines have a very low organic content.

3.2.3.4 Source Reduction

As discussed for FCC equilibrium catalyst, source reduction techniques are very difficult to formulate due to the limited number of inputs to the

According to the Oil & Gas Journal, 25% of FCC feed in the U.S. is hydroprocessed.

system. However, by employing process efficiency modifications and/or reuse procedures, catalyst fines can be diverted from landfilling. Examples include:

- Process modification installing high-efficiency cyclones on the regenerator to capture a greater percentage of fines escaping with the flue gas
- Process modification installing an ESP instead of a wet gas scrubber to enable the dry fines to be recycled

Reuse - like equilibrium catalyst, using fines as a feedstock at cement plants.

Table 3.2.11. FCC Fines Physical Properties										
Properties	# of RC	# of Unreported Values	10th %	Меал	90th %					
pН	53	51	3.8	6	8					
Reactive CN, ppm	34	70	0	17.5	10					
Reactive S, ppm	39	65	0	22. 5	100					
Flash Point, °C	33	71	60	89.9	125					
Oil and Grease, vol%	38	66	0	0.2	1					
Total Organic Carbon, vol %	31	73	0	0.12	0.35					
Specific Gravity	45	59	0.78	1.5	2.32					
Aqueous Liquid, %	63	41	0	13.9	75					
Organic Liquid, %	60	44	O	0.07	0.01					
Solid, %	95	9	56.3	90.18	100					
Particle >60 mm, %	18	86	0	0	0					
Particle 1-60 mm, %	20	84	0	15	100					
Particle 100 μm-1 mm, %	21	83	0	21.4	100					
Particle 10-100 μm, %	35	69	0	66.9	100					
Particle < 10 μm, %	27	77	0	34.6	100					
Mean Particle diameter, microns	28	76	10	56	100					

Table 3.2.12. FCC Catalyst Fines Record Sampling Locations							
Sample Number Location Description							
R2-FC-01	Shell, Wood River, IL	ESP fines					
R4-FC-02	Little America, Casper, WY	ESP fines					
R5-FC-02	Marathon, Garyville, LA	Wet scrubber fines					
R6-FC-02 Shell, Norco, LA Dewatered, wet scrubber fines							

Table 3.2.13. FCC Fines Characterization

Voletille Organica - CAS No. 108683 108383 / 106423	R2-FC-01	R4-FC-02	- 1	< 5	354	Maximum Conc 1,400 1,500	5td Dev 698 748	90% Canfidence Interval Upper Limit 925 99 t	Comments
CAS No. 75092 18889 95470	R2~FC-01 < 50 < < 50 B	R4-FC-02 50 250 87	R5-FC-02 B 140 < 50 < 50	< 50 < 50 < 50	73 100 59	140 250 87	Std Dev 45 100 19 90	00% Confidence Interval Upper Limit 109 182 74 150	Comments
CAS No. 117817 81576 90120 50553 218019 84742 85018 129000 110801	R2-FC-D1 J 250 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 330 <	R4-FC-02 165 165 330 165 165 165 165 165 165 165 165	J 75 J 190 J 160 570 J 76 J 410	J 110 J 170 J 150 < 165 < 165 < 165 < 166 < 330	239 126 118 76 171 159 266 76 350	430 170 150 76 190 180 570 76	Std Dev 140 63 46 NA 13 8 203 NA 40	90% Confidence Interved Upper Limit 353 262 218 NA 181 175 432 NA 383 NA	Commenta 1, 2 1, 2 1 1
CAS No.	R2-FC-01	R4-FC-02	85-FC-02				Std Dev	90% Confidence Interval Upper Umit 17	Comments 1, 2
Total Metels — Me CAS No. 7410905 7410360 7440362 7440362 744037 7440473 7440464 7440508 7430905 7430905 7430907 7440020 7732492 7440230 7440260 7440280 7440280	R2-FC-D1 120,000.0 47.0 11.0 160.0 13.0 1,500.0 42.0 26.0 29.0 6,000.0 34.0 48.0 48.0 48.0 49.0 49.0 49.0 49.0 49.0 49.0 49.0 49	R4-FC-02 73,000.0 8.0 1.0 590.0 1.8 2,500.0 57.0 18.0 64.0 34,000.0 210.0 20.0 780.0 3.6 5,000.0	R5-FC-02 \$4,0000 < 60 22 55,0 < 0.5 2,1000 15,0 < 5,0 6,9 1,600.0 < 6.5 73.0 < 0.5 14,000.0	Rd-FC-02 17,000.0 < 0.0 3.3 210.0 < 0.5 1,400.0 43.0 11,000.0 44.0 < 6.5 130.0 < 0.5			Std Dev 42,6563 20.5 4.5 2333 6.1 559.8 17.6 32.9 24.8 14,4207 97.5 39.5 6.8 429.8 1.5 5,168.2 1.1	Interval Upper Limit 101,099.3 33.0 6.1 444.8 6.9 2,358.4 53.0 59.7 48.5 24,960.6 144.8 83.2 15.4 822.8 2.5 11,992.7 2.5 1,850.1	Commenta
	CAS No. 108833 108383 108423 108423 108423 108423 108423 108423 108383 108423 108383 108423 108383 108423 108383 108423 108383 108423 1084	CAS No. R2-FC-01 108683 1,400 108383 / 108423 1,500 TCLP Volaitie Organics - Methods CAS No. R2-FC-01 75062 < 50 108683 50 895476	108683	CAS No. R2-FC-01 R4-FC-02 R5-FC-02 108683 1,400 < 5 < 5 5 108383 / 108423 1,500 < 6 < 5 5 5 108383 / 108423 1,500 < 6 < 5 5 5 5 108383 / 108423 1,500 < 6 < 5 5 5 5 5 5 5 5 5	CAS No. R2-FC-01 R4-FC-02 R5-FC-02 R6-FC-02 108683 1,400 < 5 < 5 < 5 < 5 < 5 < 5 < 5 < 5 < 5 <	CAS No. R2-FC-O1 R4-FC-O2 R5-FC-O2 Average Core 108893 / 1080420 1,500 5 5 5 5 5 354 354 108083 / 1080420 1,500 5 5 5 5 354 354 108083 / 1080420 1,500 5 5 5 5 354 354 108083 / 1080420 1,500 5 5 8 140 5 5 5 376	CAS No. R2 = FC - D1 R4 = FC - D2 R5 = FC - D2 R6 = FC - D2 Average Conc Maximum Conc 108383 108383 1,500 < 5 < 5 < 5 < 5 354 1,500	Votable Organica - Methods 2820A μg/hg R2-FC-02 R4-FC-02 R5-FC-02 R4-FC-02 R4-FC-02	CAS No. R2

FOC EQUILIBRIUM CATALYST FINES

	TCLP Metals - M	leihods 13f1, 60	110, 7000 , 7421	, 7410,	, 7471, aru	d 7841 mg/L			1	00% Confidence interval	
	CAS No.	R2-FC-01	R4-FC-02	, A5	-FC-02	R8-FC-02	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
Aluminum	7429205	110.00	410.00	<	1.00	4.30	131.33	410.00	192.58	289.03	
Antimony	7440360	0.89	< 0.30	<	0.30	< 0.30	0.45	0.80	0.20	0.69	
Calcium	7440702	< 25.00	100.00		58.00	68.00	60.25	100.00	30.73	85.42	
Chromium	7440473	0.24	0.34	<	0.05	< 0.05	0.17	0.34	0.14	0.29	
Cobalt	7440484	< 0.25	< 0.25	<	0.25	0.72	0.97	0.72	0.24	0.56	
Copper	7440508	0.40	0.33	<	0.13	< 0.13	0.25	9.40	0.14	0.36	
Iron	7439898	15.00	14.00		1.60	32.00	15.65	32.00	12.40	25.88	
Manganese	7430955	0.33	2.70		0.18	0.42	0.01	2.70	1.20	1.80	
Nickel	7440020	3,40	7.50	<	0.20	0.79	2.97	7.50	3.32	5.69	
Vanedium	7440622	4.90	< 0.25	<	0.25	< 0.25	1.41	4.90	2.33	3.32	
Znc	7440666	0.51	4,60		0.28	18.00	5.37	16.00	7.35	11.39	

Comments:

- 1 Delection limits greater than the highest detected concentration are excluded from the culculations.
- Upper Limit exceeds the maximum concentration.

Notes:

- B Analyte also detected in the associated method blank.

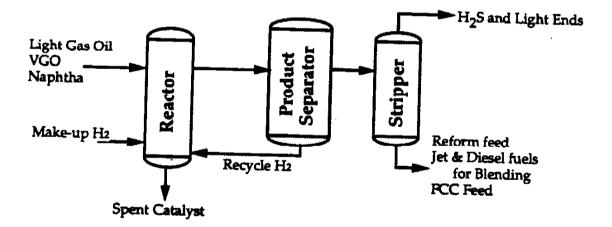
 J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification. criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

3.3 HYDROPROCESSING

3.3.1 Process Description

Hydroprocessing is used to remove organic sulfur or nitrogen from crude oil fractions ranging from heavy gas oils to naphthas. The hydrocarbon is heated and contacted with hydrogen. The mixture then passes to a fixed catalytic bed. In the reactor, organic sulfur and nitrogen are converted to H₂S and NH₃. In addition, metals that are present in the hydrocarbon (such as common crude elements vanadium and nickel) are adsorbed onto the catalyst, and some unsaturated compounds such as olefins or aromatics are saturated or cracked to form lighter compounds. After the reactor, fractionators or stabilizers separate the heavier hydroprocessed product from the newly formed ammonia, hydrogen sulfide, and light cracked gas. Typical reaction conditions are 550 to 850°F and 150 to 3,000 psi, with the more severe conditions used for heavier feedstocks (McKetta, 1992). A simplified process flow diagram for a typical hydroprocessing unit is shown in Figure 3.3.1.

Figure 3.3.1. Hydroprocessing Unit Process Flow Diagram



In 1993, refineries reported hydroprocessing capacity of approximately 10.6 million barrels per stream day in the United States (excluding Puerto Rico and the Virgin Islands). This compares to a total U.S. crude oil distillation capacity of approximately 15.6 million barrels per stream day. Therefore, hyproprocessing is used extensively in the refinery. The most common types of feeds are as follows (DOE's <u>Petroleum Supply Annual 1993</u>):

Naphtha reformer feed (38 percent of hydroprocessing capacity). Naphthas generated from distillation, cracking, and other processes often have a low octane value. To boost octane, the stock is sent to a catalytic reforming unit. However, because sulfur is a poison to the reformer catalyst the feed is almost always hydroprocessed prior to entering the reformer reactors.

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- Distillate (34 percent of hydroprocessing capacity). Distillate includes both diesel fuel and jet fuel. The 1990 Clean Air Act Amendments required the sulfur content in on-road diesel fuel to be 0.05 percent by October 1993. Many refineries have recently installed or expanded existing hydrodesulfurization reactors as a "polishing step" for their diesel fuel.
 - Historically, jet fuel has required low levels of aromatics to meet specifications; these can be removed by saturation during hydroprocessing. (Another method, clay treating, also is common but is not a hydroprocessing process).
- Heavy gas oil (18 percent of hydroprocessing capacity). Heavy gas oil is a common FCC feed. Hydroprocessing reduces SO₂ emissions in the flue gas and decreases metal loadings on the FCC catalyst.
- Other/Residual (9 percent of hydroprocessing capacity). Other hydroprocessing applications include:
 - Lubricants. Paraffinic stock is processed in the lube plant by hydroprocessing to remove organic sulfur and nitrogen, saturate aromatics, and crack waxes.
 - Gas oil/residual oil. Heavy oils may be hydroprocessed as feed to a cracking unit. The extent to which these feeds are combined with heavy gas oil for DOE's calculation purposes is not known.

The above streams are associated with fuel processing operations. One other refinery hydroprocessing application, sulfur plant tail gas treating, is associated with the facility's Claus (sulfur) plant (no fuel processing is conducted at the sulfur plant). As discussed further in Section 3.9, a significant portion of sulfur unit catalyst is generated from tail gas treating. A refinery's Claus sulfur recovery unit generates an emission stream with CO₂, H₂O, and SO₂. At facilities that further remove sulfur from this emission in a tail gas treating unit, the most common approach is first to convert the SO₂ in the offgas to H₂S by hydroprocessing. Unlike other hydroprocessing units, however, there is no fractionation following the reactor because the products are all light gases. This tail gas unit catalyst is discussed here because it more closely resembles the other hydroprocessing catalysts in characterization and management than the Claus unit catalyst.

The most common hydroprocessing catalysts are nickel/molybdenum on alumina and cobalt/molybdenum on alumina. Concentrations of cobalt or nickel are approximately 2 to 3 percent, while the concentration of molybdenum is approximately 10 percent (McKetta, 1992). Hydrocracking reactors, which conduct more extensive cracking than hydroprocessing units and commonly use a different catalyst, such as nickel/tungsten, are not included in this scope of hydroprocessing. The Agency is collecting data on hydrocracking residuals separately.

3.3.2 Hydrotreating Catalyst - Residual 6

3.3.2.1 Description

The distinction between "hydrotreating" and "hydrorefining" is not a clear one. Both fall under the broad term "hydroprocessing" because both perform similar functions of desulfurization, denitrification, and saturation. EPA has chosen to distinguish the two processes by the type of feeds and the severity of treatment. Hydrotreating involves the treatment of lighter boiling stocks under less severe conditions, while hydrorefining involves the treatment of higher boiling stocks under more severe conditions. However, exceptions to these definitions result from nomenclature used by process licensors. Hydrotreating catalyst, therefore, is used in the treatment of:

- Naphtha
- Lube oils
- Some middle distillates.

Note that the Oil & Gas Journal's annual report on Worldwide Refining defines hydrotreating to include "processes where essentially no reduction in the molecular size of the feed occurs." Subcategories of hydrotreating are identified as: (1) pretreating catalytic reformer feeds, (2) naphtha desulfurizing, (3) naphtha olefin or aromatics saturation, (4) straight-run distillate, (5) pretreating catalytic cracker feeds, (6) other distillates, (7) lube oil "polishing," and (8) other. The Agency believes that its definition, while simpler, is generally in keeping with the O&GJ definition. Further, because both hydrotreating and hydrorefining catalyst are proposed to be listed as hazardous waste, more precise definitions are not necessary.

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As stated in Section 3.3.1, both carbon (from cracking reactions) and metal deposition will poison (deactivate) the hydrotreating catalyst. Catalyst life is dependent on the severity of cracking and the metals loading; changeout occurs every 1 to 5 years. The catalyst closest to the entrance (top) of the reactor becomes deactivated first, and for this reason is sometimes replaced more frequently than the whole reactor contents (this is a "topping" operation). When catalyst activity is unacceptable, the reactor is taken out of service and undergoes one or more of the following steps to reduce the hydrocarbon content of the reactor:

Catalyst Pretreatment Steps

Nitrogen sweep	87 facilities
Hydrogen sweep	80 facilities
No preparation	22 facilities
Steam stripping	5 facilities
Oxidation	10 facilities
Other/unknown	6 facilities

Source: 125 facilities reporting in situ treatment information from RCRA §3007 questionnaire.

- Nitrogen sweep (to remove naphtha)
- Hydrogen sweep (to burn residual hydrocarbon)
- Oxidation (to burn residual hydrocarbon)
- Steam stripping or water wash (to remove volatiles).

The vast majority of refineries uses catalyst comprised of nonprecious metal oxides on alumina. Based on a total of 349 hydrotreating reactors reporting spent catalyst generation in the questionnaire, 53 percent reported using Ni/Mo catalyst, 38 percent reported using Co/Mo catalyst, and 3 percent reported using the trimetal combination of nickel, cobalt, and molybdenum on a single catalyst or as a combination of catalysts. The remaining 6 percent reported using other metals. Precious metal hydrotreating catalyst such as palladium is reportedly used in specialized applications but was not considered by EPA to be part of the scope of the study. Hydrotreating catalyst component concentrations are presented in the following table.

Fresh Hydrotreating Catalyst Component Concentrations (wt%)									
Application NiO CoO MoO ₃ P ₂ O ₅ Al ₂ O ₃									
Desulfurization		2-5	8-20	0-2	Balance				
Low severity desulfurization, denitrogenation, & olefin saturation	2-4		8-16	0-4	Balance				
Low severity desulfurization, denitrogenation, olefin saturation, PNA saturation, mild hydrocracking	3-4		15-20	4-8	Balance				

Source: Metal Catalyst Producers Panel of the Chemical Manufacturers Association.

Approximately 2,236 MT of the hydrotreating catalyst generated in 1992 was identified as displaying hazardous characteristics. This is approximately 40 percent of the total volume managed.

As a supplement to the listing determination effort, the Agency asked the catalyst reclaimers and regenerators to submit RCRA hazardous characteristic data, particularly the ignitable or self-heating properties, for the hydrotreating and hydrorefining catalyst they receive for regeneration or metals reclamation. Several

1992 Identification of Hydrotreating Catalyst from the §3007 Survey

D018 (TC benzene) 1,089 MT D001 (Ignitable) 513 MT D004 (TC arsenic) 440 MT

Total identified as hazardous: 2,236 MT (only the most common codes are listed; some streams carry multiple codes)

of the reclaimers\regenerators responded to the request and a summary of their information is presented below.

CRI-MET, a metals reclaimer, typically divides the catalyst-feed into two categories: hydrotreating (HDS) and hydrorefining (resid). HDS catalyst are those which process non-residual feeds. HDS catalyst are stripped of oil prior to dumping and contain silica, arsenic, benzene, etc. CRI-MET responded that HDS catalyst have a higher potential than resid catalyst to fail the DOT self-heating test especially as they typically are dumped oil free allowing rapid access of air to any metal sulfides present in the catalyst. Resid catalyst process residual (heavy) feeds. These catalyst are rarely free of oil prior to dumping and contain elevated levels of deposited vanadium. CRI-MET has not had any resid catalyst fail DOT's test for self-heating. The large amount of oil (10-18%) which is inherently present on these catalyst effectively seals any reactive metal sulfides from oxygen. If these catalysts were oil-free, they would probably be self-heating like the HDS catalyst. CRI-MET said that approximately 25 percent of the catalyst they receive is classified as RCRA hazardous: D001 (12.55%), D001 and other (2.14%), D003 (2.24%), D003 and other (1.15%), D001 & D003 (1.19%), and other (primarily D004 & D018) (5.8%).

CRI International, Inc. (CRII), a catalyst regenerator, provided hazardous characteristic information for the hydrotreating, hydrorefining and various petrochemical catalyst they receive for regeneration. Table 3.3.1 provides the customer classification data of the spent catalyst shipped to CRII's Lafayette, Louisiana regeneration facility. CRII also stated that due to the pyrophoric/self-heating tendency of the catalyst they experience 3 to 5 uncontrolled temperature exotherms each year in their dust collector and 5 to 7 times per year the plants have experienced uncontrolled exotherms of the spent catalyst. CRII stated that due to the "absence of a really definitive test" for self-heating characteristics these spent catalyst may or may not have been identified as potential self-heating or pyrophoric material.

Table 3.3.1. CRII Ignitability and Reactivity Data for Hydroprocessing Catalysts								
Hazardous Characteristic	1994 (tons)							
D001	1,035.4	2,017.7	533.7					
D003	0	46.8	337.7					
D001, D003	0	166.5	99.3					
D001, D018	378.5	74.4	580.2					
D003, D018	224.8	0	0					
D001, D003, D018	50.7	228.8	327.4					
Total Ignitability & Reactivity	1,689.4	2,534.3	1,878.3					
Total Regeneration	3,000	2,900	3,900					

Gulf Chemical & Metallurgical Corporation (GCMC), a catalyst metals reclaimer, also provided pyrophoric/self-heating and ignitability information for the hydrotreating and hydrorefining catalysts. GCMC conducted a study to determine the effect of hydrocarbon

content on the catalyst's flash point and the effect of the free oil content on the self-heating characteristic. The following summarizes their results.

- The catalyst flash point was reduced by adding free oil. The addition of 16% free oil reduced the flash point from 280° to 195°F. The presence of light hydrocarbons, with flash points below 140°F, could change the ignitability of spent catalyst. The study of the effect of different types of oil on the flash point was not part of this work.
- RCRA non-hazardous spent catalyst clearly exhibited self-heating characteristics when held in an oven at 140°C for 24 hours. The chemical changes increased the temperature of the sample to 257°C.
- The volume of material and the availability of oxygen affect self-heating characteristics. The temperature at the beginning of the test was between 80° and 175°C depending on depth. The heat generated in a pile of catalyst stored outdoors increased the temperature of the pile, 3 feet below the surface, to 320°C in 30 days. At 6 feet below surface, the final temperature was 235°C and 140°C at 10 feet. The temperature increase was almost linear at a rate of 7°C per day.
- Spent catalyst stored in piles exhibit self-heating and self-ignition characteristics.

3.3.2.2 Generation and Management

The spent catalyst is vacuumed or gravity dumped from the reactors. Based on information from site visits, most refineries place the material directly into closed containers such as 55-gallon drums or flow-bins. The RCRA §3007 questionnaire and site visits indicate that very few of refineries use other interim storage methods.

Ninety-two facilities reported generating a total quantity of 5,640 MT of this residual in 1992, according to the 1992 RCRA §3007 Questionnaire. Residuals were assigned to be "spent hydrotreating catalyst" if they were assigned a residual identification code of "spent solid catalyst" or "solid catalyst fines" and were generated from a process identified as a hydrotreating unit. These correspond to residual codes 03-A and 03-B, respectively, in Section VII.2 of the questionnaire and process code 06 in Section IV-1.C of the questionnaire. Quality assurance was conducted by ensuring that all hydrotreating catalysts previously identified in the questionnaire (i.e., in Section V.B) were assigned in Section VII.2. Based on the results of the questionnaire, 131 facilities use hydrotreating units and thus are likely to generate spent hydrotreating catalyst. Due to the infrequent generation of this residual, not all of these 131 facilities generated spent catalyst in 1992. However, 1992 is expected to be a typical year in regard to catalyst change-out volume and management.

Table 3.3.2 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.3.2. Generation Statistics for Spent Hydrotreating Catalyst, 1992													
Final Management	# of Streams	# of Streams w/ unreported volume	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)								
Transfer metal catalyst for reclamation or regeneration	122	8	4,274	35	100 (estimate)								
Disposal offsite in Subtitle C landfill	21	2	639	30	71								
Disposal in offsite Subtitle D landfill	20	1	408	20	56								
Reuse ¹	8	0	202	25	85								
Other offsite management ²	3	0	43	14.4	26								
Disposal in onsite Subtitle D landfill	3	0	12	4	12								
Onsite land treatment	1	0	7	7	7								
Storage/unknown offsite³	5	O	56	11	35.2								
TOTAL	184	17	5,640	31	77.4								

¹ Onsite reuse includes reuse as catalyst in the same or a similar unit, and reuse of catalyst support balls.

Plausible management scenarios were chosen by EPA on which to perform risk assessment modeling. The scenarios were chosen based on the existing and possible "high potential exposure" disposal practices currently used. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.3.2 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite Subtitle D landfilling (used for 0.2 percent of the total residual volume). An onsite monofill scenario was rejected because of the intermittent (less than once per year) generation frequency which is not typical of waste that tends to be monofilled.
- Offsite Subtitle D landfilling (used for 7 percent of the total residual volume).

The risk assessment input quantities for modeling releases using these scenarios were derived from the distribution of volumes from all management practices except for Subtitle C landfilling. These input values were greater than those associated with Subtitle D landfilling. The Agency chose this approach to determining risk assessment model input parameters after evaluating current trends in management practices. Information provided by catalyst

² Other offsite management includes incineration and stabilization.

³ Storage/unknown offsite includes (1) onsite storage with no final management and (2) transfer to an unspecified offsite facility.

reclaimers such as CRI-MET indicates that refineries have been shifting from reclamation to landfilling because of the depressed metals markets. This economic factor has made landfilling significantly more cost-effective than reclamation (aside from any potential liability reductions associated with reclamation). EPA predicted that if the risk assessment modeling were to show no basis for listing hydroprocessing catalysts, the trend to increase landfilling would be accelerated. As a result, the Agency determined that it was appropriate to consider the entire distribution of volumes reported in 1992 in creating the risk assessment inputs, rather than limiting the inputs to those catalysts reported to be landfilled in Subtitle D units. The only exception was those volumes reported to be managed in Subtitle C units which were assumed to be characteristic and thus would never be managed in Subtitle D units.

The dominant management method for this residual, transfer for offsite metals reclamation/regeneration, was not selected for modeling risks. A small number of catalyst reclaimers service the refining industry, such as CRI-MET in Louisiana and Gulf Metallurgical in Texas, and reclaim spent catalyst for its vanadium, nickel, and molybdenum metal values. EPA conducted engineering site visits to both facilities. Both of these reclamation facilities routinely manage both characteristically hazardous and nonhazardous spent catalysts. One facility segregates the hazardous and nonhazardous feedstocks but following storage, both the hazardous and nonhazardous feeds are subjected to the same process. Therefore, risks from processing are equal for both characteristic and nonhazardous wastes.

A more detailed study of the catalyst recycling industry would be a significant endeavor, and was determined to be outside the scope of this listing determination. Based on the site visits described above, EPA believes that the practice of spent catalyst reclamation is valuable because it is consistent with the intent of RCRA and because, based on EPA's preliminary review of this industry, the spent catalysts appear to be managed and processed in a way that controls risks.

Two volume scenarios were used in the risk assessment:

- Using volume statistics for all management practices except those in a Subtitle C landfill. This assumption reflects the theory that a "no-list" decision might encourage refineries to choose Subtitle D landfilling over metals reclamation (which is a cost-effective choice only when metals prices or liability concerns are high).
- Use statistics for all wastes landfilled in Subtitle D landfills. This assumption is consistent with all other landfilled wastes.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.3.3. The Agency evaluated whether to model interim storage practices, in addition to the final management practices described in Table 3.3.3. Based on the engineering site visits and sampling trips, the Agency believes that on-site

storage of these residuals is infrequent (i.e., the catalysts are only generated every 2-5 years), short term in nature due to space constraints on the unit and costs associated with container rental, and carefully controlled due to the potential pyrophoric nature of the residual (e.g., in closed flobins under an inert gas blanket).

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.3.4 provides a summary of the data for the targeted management practices used in the risk assessments for this residual. This table is developed using the RCRA §3007 survey of facilities reporting onsite landfilling of hydrotreating catalyst in any reported year. The survey specified, that if the residual was not generated in 1992, to provide the information for the last year the residual was generated.

Table 3.3.3. Selection of Risk Assessment Modeling Scenario: Spent Hydrotreating Catalyst											
Final Management	Basis for Consideration in Risk Assessment										
Transfer metal catalyst for reclamation or regeneration	Not modeled, see discussion on previous page										
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control										
Disposal in offsite Subtitle D landfill	Modeled										
Onsite reuse	Not modeled, excluded management practice										
Other offsite management ²	Not modeled, minor volumes										
Disposal in onsite Subtitle D landfill	Modeled										
Onsite land treatment	Not modeled, de minimis volume (<10 MT) unlikely to present risk										
Storage/unknown offsite ³	Not modeled, minimal volume; no defined release path of concern										

¹ Onsite reuse includes reuse as catalyst in the same or a similar unit, and reuse of catalyst support balls.

² Other offsite management includes incineration and stabilization.

³ Storage/unknown offsite includes (1) onsite storage with no final management and (2) transfer to an unspecified offsite facility. Interim storage was not modeled between release pathway would be unlikely due to widespread use of closed containers.

Table 3.3	.4. Ma	nagemen	t Practices	Cargeted f	or Risk A	ssessment								
Parameters	# of Fac.	# of RCs	# RC w/ unreported volume	Totai Volume (MT)	10th % Volume (MT)	Mean Volume (MT)	90th % Volume (MT)							
Onsite and Offsite Subtitle D Landfills ^{2,3}	13	23	1	419		20	70							
All Management		163	15	5,000		20	77.4							
Practices Except Subtitle C Landfills 1.3	Onsite Landfill Characteristics													
	Surface A	trea (acres)			0.02	7.38	30							
	Remainin	g Capacity	(cu.yd.)		280	. 30,735	838,000							
	Percent F	Remaining C	apacity		2	9	80							
	Total Ca	pacity (eu.yo	1.)		400	83,900	840,000							
	Number	of Strata in	Completed Unit		0	8	16							
	Depth Be	low Grade (ħ)		3	18	50							
	Height A	bove Grade	(ft)		0	. 0	12							
	# of Landfills: 5													
	Aquifer Information													
	Depth to	Aquifer (ft)			14	39	265							
	Distance	to Private V	Vell (ft)		3,500	8,970-	26,400							
	Populatio	n Using Pri	vate Well	***************************************	1	1	1							
	Distance	to Public W	'ell (ft)		13,200	26,400	58,000							
	Populatio	n Using Put	olic Well		1,500	1,500	1,500							
	# of Aqu	ifers: 5												
	Source: Unreport Uppermo Lowermo Combina	st ost	<u>Public</u> 3 1 1	rate										
	Current	or potential	ermost Aquifer: source of drinkin ential source of o		(4)									

¹ The number of onsite landfills characterized in this table is greater than indicated in Table 3.3.2, which focuses only on volumes generated in 1992. Table 3.3.4 incorporates data from all onsite landfills receiving catalyst in any year reported in the §3007 survey.

² The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

³ Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.3.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.3.5 summarizes the physical properties of the spent catalyst as reported in Section VII.A of the §3007 survey.
- Six record samples of spent hydrotreating catalyst were collected and analyzed by EPA. These spent catalysts represent the various types of applications and active metals used by the industry and are summarized in Table 3.3.6.

The collected samples are expected to be representative of naphtha hydrotreaters and other distillate hydrotreaters. These comprise the majority of hydrotreating applications. Five of the six samples represent naphtha feeds. This is well represented for one of the principal services of hydrotreating reactors, but does not represent other applications such as jet fuel hydrotreating. However, contaminants potentially present in naphtha feeds would likely be present in other distillate hydrocarbon feeds. Therefore, spent catalyst from these applications should be similar to spent catalyst from other feeds because the same function of desulfurization is being performed. Five of the six samples represent nickel/molybdenum catalyst. As discussed earlier, almost all reactors use Ni/Mo and/or cobalt/molybdenum, with slightly more using nickel/molybdenum. This split, therefore, is representative of most hydrotreating functions. Additionally, the samples represent different catalyst pretreatment techniques. One of the samples was taken from catalyst that did not undergo a carbon burn prior to dumping. However, it is expected to be representative because, based on the results of the RCRA §3007 questionnaire, not all catalysts undergo carbon burn.

Other hydrotreating applications account for a small percentage of the hydrotreating universe. Hydrotreating applications for lubricants include lube oil hydrotreating, wax hydrotreating, and catalytic dewaxing (used to crack waxes in lube oils) and are used by 20 facilities. According to the RCRA §3007 questionnaires, most (75 percent) of these facilities use Ni/Mo catalyst. Other catalysts such as Co/Mo, Ni/W, and palladium are used less frequently. Hydrotreating units with palladium catalyst are specifically excluded from the scope of this study because only non-precious metal catalysts were the subject of the EPA/EDF consent decree with respect to hydrotreating (based on a review of the underlying documents used in development of the consent decree language (i.e., refer to MRI report)).

Spent Ca	talyst Composition
or magazine	
Al ₂ O ₃	35-45%
Oil	0-18%
C	4-16%
V	0-10%
Ni	0-3%
Co	0-3%
Mo	6-10%
S	6-12%
Fe	0-2%
As	0-0.5%
H ₂ O	varies
F, Cl, P,	B, Si, ctc., varies

All six samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. Three of the samples were found to exhibit the toxicity characteristic for

benzene (i.e., the level of benzene in these samples' TCLP extracts exceeded the corresponding regulatory level). The high aluminum, molybdenum, nickel, and cobalt concentrations can be attributed to the catalyst make up: nickel/molybdenum or cobalt/molybdenum on alumina. A summary of the results is presented in Table 3.3.7. Only constituents detected in at least one sample are shown in this table.

Due to the pyrophoric nature of the spent catalyst, at least 2 refineries would not allow sample collection from the flow-bins once they had been sealed. One refinery requested the sample be stored in an inert atmosphere to decrease the possibility of the sample igniting. Another refinery would not allow sample collection due to a possible presence of nickel carbonyl.

Table 3.3.5. Hydi	Table 3.3.5. Hydrotreating Catalyst Physical Properties												
Properties	# of Values	# of Unreported Values	10th %	Mean	90th %								
рH	132	259	4.2	6.4	8.2								
Reactive CN, ppm	102	289	0.03	30.7	50								
Reactive S, ppm	122	269	1.0	845	160								
Flash Point, C	112	279	43.3	84	127								
Oil and Grease, vol%	59	328	0	3.6	9.0								
Total Organic Carbon, vol.%	52	339	0	4.0	10								
Specific Gravity	94	297	0.66	1.10	2.06								
BTU Content, BTU/lb	27	364	0	1,244	6,177								
Aqueous Liquid, %	179	212	0	1.3	2.0								
Organic Liquid, %	180	211	0	0.5	1.0								
Solid, %	289	102	96.5	98.8	100								
Particle > 60 mm, %	86	305	0	21	100								
Particle 1-60 mm, %	117	274	0	83	100								
Particle 100 μm-1 mm, %	81	310	0	7.8	10								
Particle 10-100 μm, %	66	325	0	2.1	1.0								
Particle < 10 μm, %	65	326	0	0.3	0								
Mean Particle diameter, microns	37	349	0	2100	3,200								

Table 3	Table 3.3.6. Hydrotreating Catalyst Record Sampling Locations												
Sample number	Facility	Description: Type of Feed, Catalyst											
R1-TC-01	Marathon, Indianapolis, IN	Naphtha reformer feed, Co/Mo catalyst											
R8A-TC-01	Amoco, Texas City, TX	FCC feed, Ni/Mo catalyst											
R3B-TC-01	Exxon, Billings, MT	Naphtha, Ni/Mo catalyst											
R11-TC-01	ARCO, Ferndale, WA	Naphtha, Ni/Mo catalyst											
R22-TC-01	Star, Port Arthur, TX	FCC feed ¹ , Ni/Mo catalyst											
R18-TC-01	Ashland, Canton, OH	Naphtha reformer/isomerization feed, Ni/Mo catalyst											

¹ A unit accepting FCC feed would typically be designated as hydrorefining; however, the generating facility designated this sample to be hydrotreating catalyst.

3.3.2.4 Source Reduction

Little can be done to reduce the quantity of these generated catalysts since, by design, they must be periodically replaced with fresh catalyst. The greatest waste minimization opportunities arise from sending these materials offsite for metals regeneration, reclamation or other reuse.

The engineering site visits reported some incremental process or treatment modifications that can result in lower volumes of spent catalyst or lower risk/toxicity. These include:

- Offsite regeneration and reintroduction to reactor results in lower volumes of catalyst being disposed or reclaimed.
- Separation of support material for onsite reuse reduces the volume of material sent offsite.
- Upstream process changes to eliminate catalyst poisons reduce the frequency of catalyst turnover.

In addition, the literature reports some operational modifications that can be used to decrease spent catalyst generation. These are summarized in Table 3.3.8.

Table 3.3.7.	Residual Characterization	Data for S	pent Hydrotreatin	g Catalyst
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											-	IUNE CONHIGERICE	
olatile Organic												int erva l	
CAS No	,		RAA-TC-01	RI1-	-TC-01	ROB-TC-01				Maximum Cano	Std Dev	Upper Limit	Comment
71432		500,000			24,000	2,000	160,000	2,900	118,363	500,000	197,487	235,384	
104518	3	12,500	50,000	<	625	3,700	< 600	2,000	11,571	50,000	19,346	23,228	
135988		12,500	17,000	<	825		< 600		5,936	17,000	7,073	10,100	
\$8066	<	12,500	< 8,250	<	625	< ' 625	J 410	< 625	410	410	NA	NA.	1
100414	ıl	280,000	110,000		13,000	5,900	J 1,100	22,000	72.000	280,000	109,622	138,055	
98828	ıl	26,000	32,000	j	600	1,300	< 800	6,000	11,450	32,000	14,001	19,888	
99878		12,500	25,000		625	J 1,250		1,800	6.963	25,000	0,059	12,904	
103651		82,000	57,000	-	1,300	3,600		10,000	22,390	62,000	28,963	39,664	
78933	<	12,500		<	625	< 625	9,500		3.525	9,500	4.134	5.359	1
100003	•	1,300,000	120,000	-	625	16,000	7,900	30,000	245,754	1,300,000	518,314	558,077	•
95836	*	310,000	220,000	`	2.500	22,000	9,700	15,000	96,533	310,000	133,714	177,108	
108678													
		120,000	62,000	J	1,000	6,500	2,500	10,000	33,677	120,000	48,143	62,697	
95476	•	370,000	140,000		11,000	12,000	3,500	45,000	97,083	370,000	143,022	183,265	
08383 / 10642		550,000	260,000		34,000	30,000	12,000	99,000	167,500	550,000	211,926	295,201	
91203	<	12,500	180,000	<	625	6,700	J 140	< 625	33,432	180,000	71,986	76,797	
												2004 C-#-4	
											•	20% Confidence	
			1311 and 8260									Interval	_
CAS No		R1-TC-01	RAA-TC-01	· H11-	-TC-01	FUB-TC-01				Maximum Conc	Std Dev	Upper Limit	Comment
75092	1	50	810		950	410			353	950	374	579	
71432		39,000	170		3,700	J 48	4,200	250	7,895	39,000	15,362	17,149	
100414	I	3,000	220	J	64	J 24	< 50	880	705	3,000	1,170	1,410	
75933	<	50	< 50	<	60	< 50	520	< 50	128	520	192	241	
106883	ı	39,000	740		1,800	210	100	4,200	7,875	39,000	15,421	16,957	
95638	1 <	50	160	<	50	< 50	< 50	120	63	160	55	110	
108678	.1.	1											
100076	! <	60	< 50	<	60	< 50	< 50	300	P2	300	102	158	
95478			< 50 340	< t							102		
95478		4,700	340		48	J 59	< 50	840	1,005	4,700	1,835	2,112	
95478	4		340 520			J 59 130	< 50 J 46	640 3,000					
95476 108383 / 19642 91203	<	4,700 13,000 50	340 520 200	1	48 160	J 59 130	< 50 J 46	640 3,000	1,005 2,808	4,700 13,000	1,835 5,110 61	2,112 5,892	
95476 198383 / 19842: 91203 Sernivotatila Org	anic	4,700 13,000 50 ss Hethod 8	340 520 200 2708 µg/kg	4	48 150 50	J 59 130 < 50	< 50 J 45 < 60	540 3,000 < 50	1,006 2,808 75	4,700 13,000 200	1,836 5,119 61	2, 112 5,892 112 10% Conflictance Interval	
95476 108383 / 10842: 91203 Sernivolatila Org CAS No	e «	4,700 13,000 50 5s Method 6 R1-TC-01	340 520 200 12708 µg/kg R&A-TC-01	₹ < R11-	48 160 60	J 59 130 < 60 RMB-TC-01	< 50 J 45 < 60 R18-TC-01	540 3,000 < 50 1222-TC-01	1,005 2,808 75 Average Conc	4,700 13,000 200 Maximum Cone	1,835 5,119 61 Std Dev	2, 112 5,892 112 10% Conflictence Interval Upper Limit	Comment
95476 108383 / 10642 91203 Semivolatila Orç CAS No 117817	anic	4,700 13,000 50 5s Method 6 R1~TC-01 580	340 520 200 200 32708 µg/kg R8A-TC-01 < 4.125	₹ < R11-	48 160 50 -TC-01	J 59 130 < 50 R3B-TC-01 < 165	< 50 J 48 < 50 R18~TC-01 J 120	\$40 3,000 < 50 \$22~TC~01 580	1,006 2,808 75 75 Average Conc 258	4,700 13,000 200 Maximum Conc 580	1,635 5,119 61 61 Std Dwy 216	2, 112 5,692 112 00% Confidence interval Upper Limit 434	1
95476 108383 / 10642 91203 Sernivolatila Org CAS No 117817 84742	anic <	4,700 13,000 50 50 es Method 8 R1~TC-01 600 500	340 520 200 200 12708 µg/kg R&A-TC-01 < 4.125 < 4.125	# R11-	-TC-01 165 165 165	J 59 130 < 50 R38-TC-01 < 165 < 165	< 50 J 48 < 50 R18~TC-01 J 120 J 110	\$40 3,000 < \$0 \$22~TC~01 \$500 < 105	1,006 2,808 75 75 Average Conc 258 110	4,700 13,000 200 Maximum Cone 580 110	1,835 5,119 61 61 Std Dwy 216 NA	2,112 5,862 192 190% Confidence Interval Upper Limit 434 NA	Comments 1 1
95476 98383 / 19642 91203 Fernivolatila Org CAS No 117817	anic <	4,700 13,000 50 5s Method 6 R1~TC-01 580	340 520 200 200 32708 µg/kg R8A-TC-01 < 4.125	# R11-	48 160 50 -TC-01	J 59 130 < 50 RBS-TC-01 < 165 < 165 < 165	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 165	\$40 3,000 < \$0 \$122~TC~01 \$500 < 165 < 165	1,006 2,808 75 75 Average Conc 258	4,700 13,000 200 Maximum Conc 580	1,635 5,119 61 61 Std Dwy 216	2, 112 5,692 112 00% Confidence interval Upper Limit 434	1
95476 08383 / 10642 91203 Fernivolatila Org CAS No 117817 84742	anic <	4,700 13,000 50 50 es Method 8 R1~TC-01 600 500	340 520 200 200 12708 µg/kg R&A-TC-01 < 4.125 < 4.125	# R11-	-TC-01 165 165 165	J 59 130 < 50 R38-TC-01 < 165 < 165	< 50 J 48 < 50 R18~TC-01 J 120 J 110	840 3,000 < 50 122-TC01 580 < 185 < 185 < 185	1,006 2,808 75 75 Average Conc 258 110	4,700 13,000 200 Maximum Cone 580 110	1,835 5,119 61 61 Std Dwy 216 NA	2,112 5,862 192 190% Confidence Interval Upper Limit 434 NA	1
95476 08383 / 10042 91203 Semivolatila Org CAS No 11787 54742 56553	anic < < <	4,700 13,000 50 5s Method 6 R1-TC-01 580 580	340 520 200 200 32708 µg/kg R8A-TC-01 < 4,125 < 4,125 J 14,000	# R11-	-TC-01 165 165 165	J 59 130 < 50 RBS-TC-01 < 165 < 165 < 165	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 165	\$40 3,000 < \$0 \$122~TC~01 \$500 < 165 < 165	1,006 2,808 75 Average Conc 258 110 2,553	4,700 13,600 200 Maximum Cone 580 110 14,000	1,835 5,119 61 Std Dev 216 NA 5,611	2, 112 5,852 112 20% Confidence Interval Upper Limit 434 NA 5,934	1
95476 91203 91203 Gernivolatila Org CAS No 117817 84742 56553 50326 80748	anic	4,700 13,000 50 55 Method 6 R1-TC-01 580 580 580	340 520 200 12708 µg/kg RBA-TC-01 < 4,125 < 4,125 J 14,000 J 14,000	# K R11-	-TC-01 165 165 165 165 165	J 59 130 < 60 R3B-TC-01 < 165 < 165 < 165 < 165	< 50 J 48 < 60 R18-TC-01 J 120 J 110 < 185 < 185	840 3,000 < 50 122-TC01 580 < 185 < 185 < 185	1,006 2,806 76 Average Conc 258 110 2,553 2,553	4,700 13,000 200 Maximum Conc 580 110 14,000 14,000	1,835 5,110 61 Std Dwv 210 NA 5,611 5,611	2,112 5,842 112 20% Conflidence Interval Upper Limit 434 NA 5,934 5,934	1
95476 91203 91203 Gernivolatia Org CAS No 117817 94742 56553 50328 20748 218016	anic VVVVV	4,700 13,000 50 50 60 600 600 600 600 600 600 600	340 520 200 12708 µg/kg RBA-TC-01 < 4,125 < 4,125 J 14,000 J 14,000 120,000	# R11-	-TC-01 165 165 165 165 165 330 165	J 59 130 < 50 RMB-TC-01 < 165 < 165 < 165 < 330 < 165	< 50 J 45 < 50 R18-TC-01 J 120 J 185 < 185 < 330 < 165	\$40 3,000 < 50 \$22-TC-01 \$50 < 165 < 165 < 165 J 92 < 165	1,005 2,808 75 Åverege Conc 258 110 2,553 2,553 20,400 4,220	4,700 13,000 200 Maximum Cone 560 110 14,000 120,000 24,000	1,835 5,110 61 Std Dev 210 NA 5,611 5,611 48,790 9,602	2, 112 5,692 112 90% Conflidence Interval Upper Limit 434 NA 5,934 5,934 49,803 10,080	1
95476 91203 91203 91203 Gernivolatila Org CAS No 117817 84742 56553 50328 80748 218016 112846	anic vvvvv	4,700 13,000 50 60 81-TC-01 600 600 600 1,320 660	340 520 200 200 32708 /g/kg R&A-TC-01 < 4,125 < 4,125 J 14,000 J 14,000 24,000 38,000	# R11-	-TC-01 165 165 165 165 165 165 165 165	J 59 130 < 50 RAB-TC-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	< 50 J 45 < 50 R18-TC-01 J 110 < 165 < 165 < 330 < 165 < 165	3,000 3,000 50 122-TC-01 580 165 165 165 165 165 172	1,006 2,808 76 5 5 5 6 6 6 6 7 6 7 6 7 7 8 7 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	4,700 13,000 200 Meximum Conc 580 110 14,000 120,000 24,000 38,000	1,835 5,110 61 Std Dev 216 NA 5,611 5,611 48,766 18,445	2, 112 5,692 112 HOS Confidence Interval Upper Limit 434 NA 5,934 49,803 10,000 15,820	1
95476 91203 91203 Gernivolatila Org CAS No 117817 84742 56552 86746 219016 112044 20044	anic < < < < < <	4,700 13,000 50 50 81 - TC - 01 500 500 500 500 500 500 500 500 500 5	340 520 200 12708 µg/kg R&A-TC-01 < 4,125 < 4,125 < 4,125 J 14,000 J 14,000 120,000 38,000	J	-TC-01 165 165 165 165 165 165 165 165	J 59 130 4 50 130 4 50 165 4 1	 50 J 46 C 60 R18-TC-01 120 J 110 C 165 C 330 C 165 C 1	\$40 3,000 < 50 \$22-TC-01 \$80 < 165 < 165 < 165 J 92 < 165 J 72 < 165	1,005 2,808 75 5 5verage Conc 2,553 110 2,553 20,400 4,230 6,538 5,887	4,700 13,000 200 Maximum Cone 580 110 14,000 120,000 24,000 38,000 34,000	1,635 5,110 01 Std Dav 210 NA 5,611 5,611 48,766 9,662 15,415 13,774	2, 112 5,602 112 90% Confidence Interval Upper Limit 434 Na 5,934 5,934 10,000 15,826 14,187	1
95476 91203 91203 6ernivolatila Org CAS No 117817 84742 56553 50326 80746 218016 132846 86737	ganic < < < < < < <	4,700 13,000 50 22 Method 6 R1-TC-01 500 500 500 600 600 600 600	340 520 200 200 88A-TC-01 < 4,125 < 4,125 J 14,000 J 14,000 24,000 38,000 34,000	# R11-	-TC-01 165 165 165 165 165 165 165 165 165	J 59 130 < 50 RMS-TC-01 < 165 < 165	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 185 < 185 < 185 < 165 < 165 < 165 < 185 < 185	\$40 3,000 < 50 \$22-TC-01 \$500 < 165 < 165 \$ 165 J 92 < 165 J 72 < 165 420	1,006 2,808 76 5,008 110 2,553 2,553 2,553 2,553 5,887 21,629	4,700 13,000 200 Maximum Cone 580 110 14,000 120,000 24,000 34,000 130,000	1,835 5,110 61 Std Dwv 210 NA 5,611 5,611 48,766 9,662 15,415 19,774 52,944	2, 112 5,692 112 90% Conflictence Interval Upper Limit 434 5,934 5,934 10,050 15,820 14,187 53,802	1
95476 91203 91203 ernivolatia Org CAS No 117817 54545 56555 50326 269016 112046 200444 86747 103678	anic < < < < < < J	4,700 13,000 50 81 - TC - 01 580 580 680 980 1,321 680 680 680	340 520 200 22708 µg/kg R&A-TC-01 < 4.125 < 4.125 J 14,000 120,000 24,000 34,000 130,000 < 4,125	J	-TC-01 165 165 165 165 165 165 165 165 165 16	J 59 130 4 50 130 4 50 100 100 100 100 100 100 100 100 100	< 50 J 45 < 50 R18-TC-01 J 120 J 105 < 165 < 330 < 165 < 165 < 165 < 165 J 310	840 3,000 < 50 322-TC-01 580 < 185 < 185 < 165 J 92 < 165 J 72 < 165	1,006 2,808 76 5,008 2,509 2,509 2,509 4,200 4,200 5,887 21,929 4,553	4,700 13,000 200 Maximum Cone 580 110 14,000 120,000 24,000 34,000 34,000 130,000 830	1,835 5,110 01 Std Dwv 210 NA 5,611 5,011 48,790 9,692 15,415 13,774 52,944 53,944	2, 112 5,692 112 90% Confidence Interval Upper Limit 434 5,934 46,803 10,050 15,824 14,157 53,602 675	1
95476 91203 91203 91203 Gernivolatila Org CAS No 117817 84742 56553 50328 86748 218016 1328446 86737 105675 95487	anic < < < < < < J	4,700 13,000 50 50 81 - TC - 01 560 560 560 660 660 660 660 670 680 680 680 680 680 680 680 680 680 68	340 520 200 12708 /g/kg FAA-TC-01 < 4,125 < 4,125 < 4,125 14,000 120,000 24,000 38,000 130,000 < 4,125 < 4,125	J	-TC01 165 165 165 165 165 165 165 165 165 16	J 59 130 4 50 130 4 50 130 4 165 4 1	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 165 <	\$40 3,000 < 50 \$22-TC-01 \$500 < 165 < 165 < 165 J 92 < 165 J 72 < 165 420 750 < 165 < 165	1,006 2,808 75 5 5 5 5 2,563 2,553 20,400 4,230 6,543 5,887 21,929 4,65 25,543	4,700 13,000 200 Maximum Conc 580 110 14,000 120,000 24,000 36,000 34,000 130,000 630 6,800	1,635 5,110 01 01 Std Dev 210 NA 5,011 5,011 48,760 9,692 15,415 13,774 52,944 303 2,600	2, 112 5,862 112 20% Confidence Interval Upper Limit 434 5,934 46,803 10,080 15,826 073 4,107	1
95476 91203 91203 91203 6ernivolatila Org CAS No 117817 84742 56553 50328 80748 218016 1120446 208446 2084737 105678 95487 NA	ganic < < < < < J	4,700 13,000 50 22 Method 6 R1-TC-01 500 500 500 500 600 1,320 600 600 270 6,800 4,200	340 520 200 200 88A-TC-01 4 4,125 4 4,125 J 14,000 120,000 24,000 34,000 34,000 130,000 4 4,125 4 4,125 4 4,125 4 4,125	J	-TC01 165 165 165 165 165 165 165 165 165 16	J 59 130 130 130 130 130 130 130 130 130 130	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 165 < 165 < 165 < 165 < 165 < 165 J 310 1,200 950	\$40 3,000 < 50 \$22-TC-01 \$500 < 165 < 165 < 165 J 92 < 165 J 72 < 165 J 72 < 165 1750 < 165 < 16	1,006 2,808 75 5 4,008 2,583 2,583 2,583 2,583 2,583 2,500 4,220 6,528 4,829 4,65 2,540 1,931	4,700 13,000 200 Maximum Cone 580 110 14,000 14,000 120,000 24,000 34,000 34,000 630 6,800 4,200	1,835 5,110 61 Std Daw 210 NA 5,611	2, 112 5,692 112 90% Confidence Interval Upper Limit 434 5,934 5,934 10,080 15,220 14,107 53,802 073 4,109 3,009	1
95476 91203 91203 91203 Gernivolatia Org CAS No 1178-17 94742 56553 50328 209046 132046 205446 85737 105675 95497 NA	anic < < < < < < J	4,700 13,000 50 22 Method 6 R1-TC-01 500 500 500 980 1,320 680 680 680 680 680 680 680 680 680 68	340 520 200 200 72708 yg/kg RBA-TC-01 < 4,125 < 4,125 34,000 120,000 24,000 34,000 130,000 < 4,125 < 4,125 < 4,125 < 4,125 < 4,125	J	-TC-01 165 165 165 165 165 165 165 165 165 16	J 59 130 4 50 130 4 50 100 100 100 100 100 100 100 100 100	< 50 J 45 < 60 R18-TC-01 J 120 J 185 < 185 < 195 < 195 < 195 J 310 1,200 950 3,400	\$40 3,000 < 50 \$22-TC-01 550 < 165 < 165 < 165 J 92 < 165 J 72 < 165 420 < 165 < 165 < 165 < 165 < 165	1,005 2,808 76 5,008 110 2,553 2,553 2,553 2,553 1,829 4,520 1,829 1,925 1,925 2,543	4,700 13,000 200 Maximum Cone 580 110 14,000 120,000 24,000 36,000 130,000 630 6,800 4,200 8,200	1,835 5,110 61 Std Dwv 210 NA 5,611 5,611 48,790 9,602 15,415 13,774 52,944 303 2,600 1,854 3,032	2, 112 5,692 112 90% Confidence Interval Upper Limit 434 5,934 5,934 49,803 10,050 15,826 14,187 53,602 073 4,109 3,008 4,800	1
95476 91203 91203 91203 ernivolatila Org CAS No 117817 84742 56552 50328 86746 218016 1320446 86737 105675 95467 NA	anic vvvvvvJ v	4,700 13,000 50 50 81-TC-01 560 660 680 680 680 680 680 680 680 880 680 880 8	340 520 200 200 12708 pg/kg RAA-TC-01 4 4,125 4 4,125 4 4,125 4 4,125 4 4,125 4 4,125 4 4,125 4 4,125 4 4,125	F11-	-TC-01 165 165 165 165 165 165 165 165 165 16	J 59 130 4 50 130 4 50 130 4 165 4 1	< 50 J 45 < 60 R18-TC-01 J 120 J 110 < 165 <	3,000 3,000 3,000 322-TC-01 580 4 165 4 165 4 165 4 20 7 50 4 165 4 165 4 165 4 165 4 105 4	1,006 2,808 75 5 5 5 5 2,563 2,563 2,563 2,563 4,230 4,230 4,230 4,535 5,887 21,829 465 2,543 1,951 2,976 84,809	4,700 13,000 200 Maximum Conc 580 110 14,000 120,000 24,000 36,000 34,000 130,000 6,800 6,800 4,200 4,200	1,635 5,110 01 01 Std Dav 210 NA 5,011 5,0	2, 112 5,862 112 20% Confidence Interval Upper Limit 434 5,934 46,803 10,090 15,826 14,187 53,602 07,307 4,109 3,008 4,803 185,238	1
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Di-n-butylphthelate
Benz(a)anihracena
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Fluorenthane
Fluorene
2,4 - Olmethylphanol
2~Methylphenoi
3/4 - Methylphenol
Phenol
Phananthrane
Pyrene
1—Methylnaphthalane
2—Methylnaphthalane
2—Methylichrysene

Naphthatana

Benzene n-Butylbenzens sec-Butylbenzene tert-Butylbenzene Ethylbenzene kapropylbenzene p-teopropytiolune n-Propythenzene Methyl ethyl kelona

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90% Confidence

HYDROTHEATHIS CATALYST

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90% Carlidence Interval Upper LIMI

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•	Constitution	170	4	611.5		4.5	1,000.3	21.0	11,001,11	10.0	2,120.1	90.0	47.2	27,000.8	10,000.8	78.6	3,524.2	0.7	1,319.4	502	9		StdDev	37.11	1.05	0.02	72.64	125.10	22.07	7.	15.00	127.20	2.00	0.0
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	T AIG	330,000	30.0	0.99	2.5	2.6	2,600.0	9.0	25.0	12.5	1,100.0	38.0	7.6			1000	2,500.0	2	1600	20			RIB-TC-03	88	80	0.0	12.80 A	0	38.	0.30	8	31000	0.13	0.25
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	100 / 100 /		30.0	120.0	2.5	12.0	2,500.0	0.8	26,000.0	023	6.000.0	9.6	7.8	81,000.0	0.00	65.0 A	2,500.0). A	3000	10.0		2010, 0010	R1-10-01 F	8	900	900	8,8	310.00 <	9.6	0.22	B.15	0.01	0.25	0.10
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CBI reducted information falls within the range of concentrations of other samples.

- Analye also detected in the associated method blash.

 Correcurd's concentration is estimated. Mess specified date habete the presence of a compound that mays the identification related for the configuration is easily as the informatory detection that, but greater than saro.

 Not Detected.

 Not Applicable. ш ¬
- 9 ≨

Table 3.3.8. Documented Source Reduction Op	tions for Hydrotreating Catalyst
Reference	Waste Minimization Methods
McKetta, 1992	Guard columns can be used to adsorb metals that would otherwise deactivate the main column.
Monticello, D.J. "Biocatalytic Desulfurization." Hydrocarbon Processing. February 1994.	Material substitution (eliminating use of metallic catalysts).
"NPRA Q&A 1: Refiners Focus on FCC, Hydroprocessing, and Alkylation Catalyst." Oil & Gas Journal. March 28, 1994.	Regeneration. Top-bed skimming.
Gorra, F., Scribano, G., Christensen, P., Anderson, K.V., and Corsaro, O.G. "New Catalyst, Improve Presulfiding Result in 4+ Year Hydrotreater Run." Oil & Gas Journal. August 23, 1993.	Material substitution.
"Petroleum-derived Additive Reduces Coke on Hydrotreating Catalyst." Oil & Gas Journal. December 27, 1993.	Process modification.
Berrebi, G., Dufresne, P., and Jacquier, Y. "Recycling of Spent Hydroprocessing Catalysts: EURECAT Technology." Environmental Progress. May 1993.	Metals reclamation.

3.3.3 Hydrorefining Catalyst - Residual 7

3.3.3.1 <u>Description</u>

Hydrorefining catalyst is generated in a manner similar to hydrotreating catalyst. Units generating hydrorefining catalyst include the following:

- Gas oil desulfurization
- Residual desulfurization
- Desulfurization of some middle distillates.

Note that the Oil & Gas Journal's annual report on Worldwide Refining defines hydrorefining to include "process where 10% of the feed or less is reduced in the molecular size." Subcategories of hydrorefining are identified as: (1) residual desulfurization, (2) heavy gas oil desulfurization, (3) catalytic cracker and cycle stock, (4) middle distillate, and (5) other. The Agency believes that its definition, while simpler, is generally in keeping with the O&GJ definition.

The poisoning mechanisms for hydrorefining catalyst are similar to those for hydrotreating catalyst and catalyst removal is conducted in the same way. However, some facilities take great care to keep the hydrorefining catalyst in an inert atmosphere during all phases of catalyst removal. This is because ferric sulfide, a byproduct of the reaction, can react with oxygen and cause pyrophoricity.

When catalyst activity is unacceptable (every 1 to 5 years), the reactor is taken out of service and undergoes one or more of the following steps to reduce the hydrocarbon content of the reactor:

- Nitrogen sweep (to remove naphtha)
- Hydrogen sweep (to burn residual hydrocarbon).

The vast majority of refineries uses catalyst comprised of nonprecious metal oxides on alumina. Based on a total of 114 hydrorefining reactors reporting spent catalyst

Catalyst Pretreatment Steps

Nitrogen sweep 41 facilities
Hydrogen sweep 37 facilities
No preparation 5 facilities
Neutralization/ 11 facilities
other/unknown

Source: 53 facilities reporting in situ treatment information from RCRA §3007 questionnaire.

generation in the questionnaire, 50 percent reported using Ni/Mo catalyst, 35 percent reported using Co/Mo catalyst, and 11 percent reported using the combination of nickel, cobalt, and molybdenum (either as one catalyst or as a mixture of catalysts). The remaining 4 percent report using miscellaneous combinations of these metals. Usage of precious metal hydrorefining catalyst, if any, was not investigated by EPA as part of the scope of the study. Hydrorefining catalyst component concentrations are presented in the following table.

Approximately 5,028 MT of hydrorefining catalyst generated in 1992 were identified as displaying hazardous characteristics. This is approximately 27 percent of the total volume managed. For more information on hazardous characteristics and the pyrophoric or self-heating tendencies of hydrotreating and hydrorefining catalysts refer to Section 3.3.2.1.

1992 Identification of Hydrorefining Catalyst

D018 (TC benzene) 3,164 MT D001 (Ignitable) 1,671 MT D004 (TC arsenic) 755 MT

Total identified as hazardous: 5,028 MT (only the most common codes are listed; some streams carry multiple codes)

Fresh Hydrorefining Catalyst Component Concentrations (wt%)												
Application	CoO	MoO ₃	P ₂ O ₅	Al ₂ O ₃								
Fixed bed, NiMo	2-5		12-18	0-7	Balance							
Fixed bed, CoMo	vor age.	2-5	12-18	0-5	Balance							
Ebullating bed	3-4		12-18	0-2	Balance							

Source: Metal Catalyst Producers Panel of the Chemical Manufacturers Association.

3.3.3.2 Generation and Management

The spent catalyst is vacuumed or gravity dumped from the reactors. Based on information from site visits, most refineries place the material directly into closed containers such as 55-gallon drums or flow-bins. The RCRA §3007 questionnaire and site visits indicate that few refineries use other interim storage methods.

Thirty-eight facilities reported generating a total quantity of 18,634 MT of this residual in 1992, according to the 1992 RCRA §3007 questionnaire. Residuals were assigned to be "spent hydrorefining catalyst" if they were assigned a residual identification code of "spent solid catalyst" or "solid catalyst fines" and were generated from a process identified as a hydrorefining unit. These correspond to residual codes 03-A and 03-B, respectively, in Section VII.2 of the questionnaire and process code 07 in Section IV-1.C of the questionnaire. Quality assurance was conducted by ensuring that all hydrorefining catalysts previously identified in the questionnaire (i.e., in Section V.B) were assigned in Section VII.2. Based on the results of the questionnaire, 58 facilities use hydrorefining units and thus likely generate spent hydrorefining catalyst. Due to the infrequent generation of this residual, not all of these 58 facilities generated spent catalyst in 1992. However, 1992 is expected to be a typical year in regard to catalyst change-out volume and management.

Table 3.3.9 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.3.9. Generation Statistics for Spent Hydrorefining Catalyst, 1992								
Final Management	# of Streams	# of Streams with unreported volume	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)			
Transfer metal catalyst for reclamation or regeneration	63	o	15,359	244	500 (estimate)			
Disposal offsite in Subtitle D landfill	5	0	2,348	470	2,0991			
Disposal onsite in Subtitle D landfill	1	0	700	700	700			
Disposal offsite in Subtitle C landfill	2	0	198	99	151			
Offsite recycle	1	0	29	29	29			
TOTAL	72	0	18,634	255	500			

¹ This particularly high volume was verified with the generating facility; the spent catalyst was generated from a large unit.

Plausible management scenarios were chosen by EPA on which to perform risk assessment modeling. The scenarios were chosen based on the existing and possible "high potential exposure" disposal practices currently used. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.3.9 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment.

The selected management practices are:

- Onsite Subtitle D landfilling (used for 4 percent of the total residual volume).

 An onsite monofill scenario was rejected because of the intermittent (less than once per year) generation frequency which is not typical of waste that tends to be monofilled.
- Offsite Subtitle D landfilling (used for 13 percent of the total residual volume)

The input quantities for modeling releases using these scenarios were greater than those actually landfilled in 1992. Instead, the management quantity is assumed to be the total quantity generated (minus that managed in Subtitle C units already). This is because other management methods, in particular reclamation, could change to landfilling in the future due to economic factors, convenience, or other factors. See Section 3.3.2.2 for additional details.

As with the hydrotreating catalyst, the Agency determined that it was unnecessary to model interim storage prior to final management.

The management method accounting for the majority of the residual, transfer for offsite metals reclamation/regeneration, was not selected for modeling risks. A small number of catalyst reclaimers, such as CRI-MET in Louisiana and Gulf Metallurgical in Texas, reclaim spent catalyst for its vanadium, nickel, and molybdenum metal values. Both of these reclamation facilities routinely manage both characteristically hazardous and nonhazardous spent catalysts. One of these facilities segregates the hazardous and nonhazardous feedstocks, but following storage, both the hazardous and nonhazardous feeds are subjected to the same process. Therefore, risks from processing are equal for both characteristic and nonhazardous wastes.

A more detailed study of the catalyst recycling industry would be a significant endeavor, and was determined to be outside the scope of this listing determination. Based on the site visits described above, EPA believes that the practice of spent catalyst reclamation is valuable because it is consistent with the intent of RCRA and because, based on EPA's preliminary review of this industry, the spent catalysts appear to be managed and processed in a way that controls risks.

Two volume scenarios were used in the risk assessment:

- Using volume statistics for all management practices except those in a Subtitle C landfill. This assumption reflects the theory that a "no-list" decision would encourage refineries to choose Subtitle D landfilling over metals reclamation (which is a cost-effective choice only when metals prices or liability concerns are high).
- Use statistics for all wastes landfilled in Subtitle D landfills. This assumption is consistent with all other landfilled wastes.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.3.10.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.3.11 provides a summary of the data for the targeted management practices used in the risk assessment for this residual. This table is developed from facilities reporting onsite landfilling of hydrorefining catalyst in any year according to the RCRA §3007 survey.

Table 3.3.10. Selection of Risk Assessment Modeling Scenario: Spent Hydrorefining Catalyst					
Final Management	Basis for Consideration in Risk Assessment				
Transfer metal catalyst for reclamation or regeneration	Not modeled, see discussion on previous page				
Disposal offsite in Subtitle D landfill	Modeled				
Disposal onsite in Subtitle D landfill	Modeled				
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control				
Offsite recycle	Not modeled, exempt management practice				

Table 3.3.11. Management Practices Targeted for Risk Assessment								
Parameters	# of Fac.	# of RCs	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)	
Onsite and Offsite Subtitle D Landfills ²³	5	6	0	3,048	_	37.25	2,250	
All Management		71	0	18,436		88	500	
Practices Except Subtitle C Landfills ^{1,3}	Onsite Landfill Characteristics							
	Surface	Arca (ac	ercs)		4.8	7.7	30	
	Remain	ing Capa	city (cu.yd.)	6,970	70,500	838,000		
	Percent	Remaini	ng Capacity		2	3.5	80	
	Total C	Capacity (cu.yd.)	82,300	85,500	840,000		
	Numbe	r of Strat	a in Completed Unit	0	8	16		
	Depth	Below Gr	ade (ft)		3	18	50	
	Height	Above G	rade (ft)	0	1.5	12		
	# of Landfills: 4							
	Aquifer Information							
	Depth	to Aquife	r (ft)		14	34.5	97	
	Distanc	e to Priv	ate Well (ft)		3,500	7,585	26,400	
	Popula	tion Usin	g Private Well		1	1	1	
	Distance	e to Pub	io Well (ft)		26,400	42,200	58,000	
	Popula	tion Usin	g Public Well		1,500	1,500	1,500	
	# of Aquifers: 4							
	Source Unrepo Upper Lower Combin	nost most mation	Public 3 0 1 0 0	1 1 1	ivate			
	Classification of Uppermost Aquifer: Current or potential source of drinking water (0) Not considered a potential source of drinking water (4)							

¹ The number of onsite landfills characterized in Table 3.3.11 is greater than indicated in Table 3.3.9, which focuses only on volumes generated in 1992. Table 3.3.11 incorporates data from all onsite landfills receiving catalyst in any year reported in the §3007 survey.

² The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

³ Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.3.3.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.3.12 summarizes the physical properties of the spent catalyst as reported in Section VII.A of the §3007 survey.
- Three record samples of spent hydrorefining catalyst were collected and analyzed by EPA. These spent catalysts represent the various types of applications and active metals used by the industry and are summarized in Table 3.3.13.

These samples are representative of two important feeds to hydrorefining units, heavy gas oil and diesel fuel. As discussed earlier, almost all hydrorefining reactors use Ni/Mo and/or cobalt/molybdenum, with slightly more using nickel/molybdenum. Both catalyst types are represented by the sampling.

All three samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. One of the samples was found to exhibit the toxicity characteristic for benzene (i.e., the level of benzene in this sample's TCLP extract exceeded the corresponding regulatory level). Two samples were found to exhibit the toxicity characteristic for arsenic. The high aluminum, molybdenum, nickel, and cobalt concentrations can be attributed to the catalyst make up: nickel\molybdenum or cobalt\molybdenum on alumina. A summary of the results is presented in Table 3.3.14. Only constituents detected in at least one sample are shown in this table.

At one refinery, the spent hydrorefining catalyst was collected by refinery personnel on supplied air because of high airborne arsenic concentration levels.

3.3.3.4 Source Reduction

All source reduction efforts and limitations tabulated for hydrotreating catalyst (Section 3.3.2.4) are applicable for hydrorefining catalyst.

Table 3.3.12. Hydrorefining Catalyst Physical Properties								
Properties	# of Values	# of Unreported Values	10th %	Mean	90th %			
pН	53	71	4.9	6.7	9.2			
Reactive CN, ppm	34	90	0	4.7	10			
Reactive S, ppm	52	72	0.25	892	100			
Flash Point, C	46	78	48.9	87	110			
Oil and Grease, vol%	31	93	0	22	12.5			
Total Organic Carbon, vol%	23	101	0	7.0	21			
Specific Gravity	46	78	0.7	1.45	2.5			
BTU Content, BTU/lb	13	111	0	1,684	4,700			
Aqueous Liquid, %	54	70	0	3.6	17			
Organic Liquid, %	50	74	0	1.0	3.75			
Solid, %	92	32	83	97	100			
Particle > 60 mm, %	28	96	0	4	0			
Particle 1-60 mm, %	47	77	50	8 9	100			
Particle 100 µm-1 mm, %	36	88	0	6.7	25			
Particle 10-100 μm, %	29	95	0	4.6	7.5			
Particle <10 μm, %	26	98	0	0.3	0			
Mean Particle diameter, microns	19	104	0.	1,344	3,175			

Table 3.3.13. Hydrorefining Catalyst Record Sampling Locations						
Sample number	Facility	Description: Type of Feed, Catalyst				
R5-TC-01	Marathon, Garyville, LA	Heavy gas oil, Co/Mo catalyst				
R7B-TC-01	BP, Belle Chasse, LA	Diesel, Ni/Mo catalyst				
R21-RC-01	Chevron, Port Arthur, TX	Diesel, Co/Mo catalyst				

Table 3.3.14. Residual Characterization Data for Spent Hydrorefining Catalyst

							1	90% Confidence		
	Volatile Organics							interval		
	CAS No.	R5-TC-01	R78-RC-01	R21-RC-01	Average Conc.	Maximum Conc.	Eld Dev	Upper Limit	Comments	
Benzene	71432	4,200	100,000	27,000	43,733	100,000	50,044	98,225		
n - Butylbenzene	104518			10,000	3,790	10,000	5,367	9,646		
sec -Buty/benzene	135988	J 940		5,300	2,250	5,300	2,650	5,136		
Ethylbenzene	100414	J 1,200	23,000	J 4,800)	9,667	23,000	11,080	22,392		
Isopropyibenzime	98828	< 625	1,600	< 2,500	1,113	1,600	669	2,613	1, 2	
p-laopropytoùene	99870	< 625	< 625	5,500	2,250	5,500	2,815	5,315		
Mathylene chloride	76092	< 625	< 626	J 2,900	1,383	2,000	1,313	2,814		
Nachthalene	91203	< 625	J 980	J 2,900	1,495	2,000	1,226	2,832		
n-Propylbenzene	103851	J 900	2,000	< 2,500	1,450	2,000	778	3,143	1,2	
Tetrachloroethene	127184	< 625	< 625	9,500	3,583	9,500	5,124	9,163		
Tolume:	108883	5,700	190,000	13,000	69,587	100,000	104,362	183,205		
1,2,4 Trimotylbenzene	95630	1,900	5,400	23,000	10,433	23,000	11,113	27,534		
1.3.5 - Trimetrylbenzene	108678	< 625	2,500	5,900	3.042	5,900	2.665	5,044	2	
o-Xylene	95476	1,400	24,000	6.900	10,787	24,000	11,780	23,500	-	
m.p.—Xylenes	108383 / 10642	.,				78,000	38.301	76,637		
mp species	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	-,,,,,	, -,001		,	,,	,,	, 5,551		
	1									
	4							90% Confidence		
	TCLP Volatile O	rcanica - Metho	ds 1311 and 8266	OA LADAL				Interval		
	CAS No.		R78-AC-01		Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments	
Acelone	67641				70	110	35	108		
Benzene	71430	110	1	160	1,490	4,200	2,347	4,045		
Ethylbenzene	100414	< 50		< 50	80	140	52	137		
Mathylene chloride	75092	< 50	3 t	100	67	100	20	98		
Toluene	108893				1,387	4,000	2,281	3,850	,	
1,2,4-Trimetylbenzene	95636				93	150	75	175		
o-Xylene	95470			< 50	83	150	58	140		
m_p_Xylene	108383 / 10642				210	530	277	512		
III D- What a	100000 100 14		, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		,	,				
							1	90% Confidence		
	Semivolatie Org	ganica - Method	8270B µg/kg					Interval		
	CAS No.	R5-TC-01	A7B-RC-01	R21-RC-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments	
Acenaphthene	83329	< 185	< 1.650	370	258	370	145	583	1,2	
Benzo(g.h.i)peytene	191242	480	< 1,650	< 165	313	460	209	767	1, 2	
Dibenzoluran	132649	< 165	J 1,100	J 220	495	1,100	525	1,000		
2.4-Dimetrylphenol	105679	< 165	5,900	390	2,152	5,000	3,248	5,688		
Dimetry phthelate	131113	< 165			208	250	50	338	1, 2	
Di-n-butyi phihalata	87742	< 165	< 1,850	J 210	188	210	32	257	1, 2	
2.4-Dinitrophenol	51285	< 800	< 8,000	J 370	370	370	NA	NA	3	
2.4-DinitrotoLene	121142	< 165	< 1,550	J 240	203	240	53	318	1,2	
Bis (2 - of) yhery() phthe iste	117817				110	110	NA	NA	1	
Fluorene	60737	< 105	J 2,800	800	1,255	2,600	1,375	2,752		
Isochorone	76501	< 155		j 150	150	150	NA	NA	1	
2-Methylchrysene	3351324	3,400		< 330	2,343	3,400	1,744	4,243	2	
1-Mehvisaphhalene	90120	_,		2,900	4,007	8,630	4,152	8,528		
2 - Methylnaphthalene	01576			5,100	5,755	12,000	5,945	12,228	2	
2 - Methylphenol	95487	< 165		-,	2,008	5,600	3,111	5,396		
3/4-Methylchenol	NA.	< 105			712	1,600	943	1,738		
Nechthalana	91203			580	1,240	3,000	1,531	2,916		
Phenanthrene	85018	< 105		1,200	1,188	2,200	1,018	2,296	2	
Phenol	108952	< 165	-,		710	1,630	044	1,738		
Pyrreines	129000	3.300		540	1.847	3.300	1.347	0,313	2	
Pyridine	110851	-,	- · · · ·	10,000	4,543	10,000	4,953	9,937		
1 Justin	,			()	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,					

HYDROREFINING CATALYST

Bis(2-ethythexyi) phthalab
Carbazota
2,4-Dimethylphenol
Dimetrylphthelate
1 – Methylnachthalane
2 - Methylmaphthalene
2 - Methylphenol
3/4 - Methylphenol (total)
Naphthalene
Phenol

Aluminum
Antimony
Arsenic
Berytlaum
Cadmium
Chromium
Cobalt
Copper
iran Coppu
Lend
Molybdenum
Nickel
Selenium
Thelium
Vanadium

Aluminum Antimony Arsenic Cobelt Iron Mangenese Molybdenum Nicke Variadium Zino

							,	90% Confidence	
			ethoda 1311 and					intervaj	
CAS No.			A78-RC-01			Maximum Conc	Std Dev	Upper Limit	Comments
117817		3,100			1 1	-,	1,770	2,984	
85748		100			17	17	NA	NA	1
105079		50			100	220	104	214	
131113		50		1	34	34	NA.	NA	1
90120		100			100	280	104	273	
Q157 0		50			173	420	214	406	
95467	<	50		J 70	137	250	133	282	
NA.	<	50				150	54	147	
P1203	<	50				170	6 0	165	
108952	JB	17	160	130	102	160	75	184	2
								90% Contidence	
ial Melais — I	Meti	oda 5010, 70	60,7421,7470,	7471, and 7841 m	ng/kg		1	90% Cantidence Interval	
tal Metals — I CAS No.	Met	oda 5010, 70 R5-TC-01				Maximum Conc	Std Dav		Comments
			R78-RC-01	R21-RC-01	Average Conc			Interval	Comments 2
CAS No.		R5-TC-01	R78-RC-01 80,000.0	R21-RC-01 170,000.0	Average Conc 173,339	270,000	Std Dav	Interval Upper Limit	
CAS No. 7420005		R5-TC-01 270,000.0	R78-RC-01 80,000.0	R21-RC-01 170,000.0	Average Conc 173,339	270,000	Std Dev 95,044	Interval Upper Limit 276,825	
CAS No. 7429005 7440360		R5-TC-01 270,000.0 44.0	R78-RC-01 80,000.0 380.0 650.0	R21-RC-01 170,000.0 < 30.0 730.0	Average Conc 173,333 151.3	270,000 390.0 730.0	Std Dev 95,044 196.2	Interval Upper Limit 276,825 367.1	2
CAS No. 7429005 7440360 7440362		R5-TC-01 270,000.0 44.0 100.0	R78-RC-01 80,000.0 380.0 650.0	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5	Average Conc 173,333 151.3 493.3	270,000 390.0 730.0	Std Dev 95,044 198.2 343.0	Interval Upper Limit 276,825 307.1 860.8	2
CAS No. 742905 7440360 7440362 7440417		R5-TC-01 270,000.0 44.0 100.0 43.0	R78-RC-01 80,000.0 380.0 550.0 < 0.5 5.2	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5	Average Corc 173,333 151.3 493.3 15.3 5.5	276,000 380.0 730.0 43.0	Std Dev 95,044 196.2 343.0 24.0	Interval Upper Limit 276,825 307.1 866.8 41.4	2
CAS No. 742005 7440360 7440362 7440417 7440439		R5-TC-01 270,000.0 44.0 100.0 43.0 8.7	R78-RC-01 80,000.0 380.0 550.0 < 0.5 5.2	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5	Average Corc 173,333 151.3 493.3 15.3 5.5	270,000 380.0 730.0 43.0 8.7	Std Dev 95,044 198.2 343.0 24.0 3.1	Interval Lipper Limit 276,825 367.1 866.8 41.4 8.9	2
CAS No. 7420905 7440360 7440362 7440417 7440439 7440473		R5-TC-01 270,000.9 44.0 100.0 43.0 8.7 33.0	R78-RC-01 80,000.0 880.0 650.0 < 0.5 5.2 6.7	R21-RC-01 170,000.0 < 30.0 730.0 < 2.6 < 2.5 < 5.0	Average Conc 173,333 151.3 493.3 15.3 5.5 14.9	270,000 380.0 730.0 43.0 8.7 33.0	Std Dev 95,044 196.2 343.0 24.0 3.1 15.7	Interval Upper Limit 276,825 367. t 866.8 41.4 8.9 32.0	2
CAS No. 7420905 7440360 7440362 7440417 7440439 7440473 7440484		R5-TC-01 270,000.0 44.0 160.0 43.0 8.7 33.0 18,000.0	R78 -RC-01 80,000.0 880.0 650.0 < 0.5 5.2 6.7 8,700.0	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5 < 5.0 24,000.0	Average Corc 173,333 151.3 493.3 153 55 149 16,900.0	270,000 380.0 730.0 43.0 8.7 33.0 24,000.0	\$1d Dev 95,044 196.2 343.0 24.0 3.1 15.7 7,709.1	Interval Upper Limit 278,825 307.1 806.8 41.4 8.9 32.0 25,294.3	2 2 2
CAS No. 7420005 7440360 7440362 7440417 7440439 7440473 7440484 7440508		R5-TC-01 270,000.0 44.0 160.0 43.0 8.7 33.0 18,000.0	Ř78RC 01 80,000.0 380.0 650.0 < 0.5 5.2 8.7 8,700.0 17.0 470.0	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5 < 5.0 24,000.0 32.0	Average Conc 173,339 151,3 493,3 153,5 5,5 149,16,900,0 31,7	270,000 380.0 730.0 43.0 8.7 33.0 24,000.0 46.0	Std Dev 95,044 196 2 343.0 24.0 3.1 15.7 7,709.1	Interval Upper Limit 276,825 367.1 806.8 41.4 8.9 32.0 25,294.3 47.5	2 2 2 2 2
CAS No. 7420005 7440360 7440362 7440417 7440439 7440473 7440484 7440506 7430896		R5-TC-01 270,000.9 44.9 100.0 43.0 8.7 33.0 18,000.0 46.0 730.0	R78~RC~01 80,000.0 380.0 650.0 < 0.5 5.2 6.7 8,700.0 17.0 470.0 < 0.3	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5 < 5.0 24,000.0 32.0 1,100.0	Average Corc 173,333 151.3 493.3 15.3 5.5 14.9 16,900.0 31.7 766.7	270,000 380.0 730.0 43.0 8.7 33.0 24,000.0 46.0 1,100.0	Std Dev 95,044 196.2 343.0 24.0 3.1 15.7 7,709.1 14.5 316.0	Interval Upper Limit 276,825 367.1 800.8 41.4 8.9 32.0 25,294.3 47.5 1,111.4	2 2 2 2 2
CAS No. 742005 744030 744032 744047 744043 744043 744084 744050 743080 743092		R5-TC-01 270,000.0 44.0 100.0 43.0 8.7 33.0 18,000.0 46.0 730.0	Ř78 –ŘC – 01 80,000,0 380,0 650,0 < 0,5 5,2 6,7 8,700,0 17,0 470,0 < 0,3 25,000,0	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5 < 5.0 24,000.0 32.0 1,100.0 2.8 77,000.0	Average Conc 173,333 151,3 493,3 153, 65, 149, 16,900,0 31,7 766,7	270,000 389.0 730.0 43.0 8.7 33.0 24,000 46.0 1,100.0 2.8	\$1d Dev 95,044 196.2 343.0 24.0 3.1 15.7 7,709.1 14.5 316.6 1.3	Interval Upper Limit 276,825 367.1 800.8 41.4 8.9 32.0 25,294.3 47.5 1,111.4 2.8	2 2 2 2 2
CAS No. 742005 7440302 7440362 7440457 7440479 7440478 74404047 7440508 7430905 7430907		R5-TC-01 270,000.9 44.0 100.0 43.0 8.7 33.0 18,000.0 46.0 730.0 1.3 74,000.0	Ř78~ŘC~01 80,000.0 380.0 650.0 < 0.5 5.2 6.7 8,700.0 17.0 470.0 < 0.3 25,000.0 < 8.0	R21-RC-01 170,000.0 < 30.0 730.0 < 2.5 < 2.5 < 5.0 24,000.0 32.0 1,100.0 2,000.0 650.0	Average Conc 173,333 1513 4933 153 55 149 16,900,0 31,7 766,7 1 58,666,7 4,952,7	270,000 389.0 730.0 43.0 8.7 33.0 24,000.0 48.0 1,100.0 2.8 77,000.0	\$1d Dev 95,044 198-2; 343-0 24.0 3.1 15-7; 7,709.1 14-5 316-0 1.3 29,194.7	Interval Upper Limit 276,825 367.1 906.8 41.4 8.9 32.0 25,294.3 47.5 1,111.4 2.6 90,456.3	2 2 2 2 2
CAS No. 742005 7440300 7440405 7440439 7440439 7440508 7430805 7430807 744020		R5-TC-01 270,000.9 44.0 100.0 43.0 8.7 33.0 18,000.0 46.0 730.0 1.3 74,000.0	Ř78ŘC 01 80,000.0 380.0 550.0 < 0.5 5.2 6.7 8,700.0 17.0 470.0 < 0.3 25,000.0 < 8.0	R21-RC-01 170,000.0 < 30.0 < 730.0 < 2.5 < 2.5 < 2.6 24,00.0 32.0 1,100.0 2.8 77,000.0 850.0	Average Conc 173,333 151.3 493.3 15.3 5.5 14.9 16,900.0 31.7 766.7 1.5 58,666.7 4,952.7 21.2	270,000 380.0 730.0 43.0 8.7 33.0 24,000.0 46.0 1,100.0 2.8 77,000.0 14,000.0	Std Dev 95,044 198.2 343.0 24.0 3.1 15.7 7,709.1 14.5 316.6 1.3 29,194.7 7,846.5	Interval Upper Limit 276,825 367.1 866.8 41.4 8.9 32.0 25,294.3 47.5 1,111.4 2.8 90,456.3 13,496.8	2 2 2 2 2

									90% Cantidence	
TCLP Metals	Mel	hods 1311, B		Interval						
CAS No.		R5-TC-01	R78-RC-01		R21-RC-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
7423905		4.40	< 1.00	<	1.00	2.13	4.40	1.00	4.27	
7440360	<	0.30	9.60	<	0.30	3.40	9.60	5.37	9.25	
7440382		0.23	34.00	1	8.90	13.71	34.00	17.59	33.19	
7440484		55.00	160.00	i	190.90	135.00	160,00	70.89	212.10	2
7439896		3.30	8.20	l	19.00	9.50	19.00	8.35	18.60	
7439965		0.17	< 0.08		0.29	0.18	0.29	0.1\$	0.30	2
7430987	<	00.1	13.00		£7.00	10.33	17.00	8.33	19.40	2
7440020		67.00	0.73		\$7.00	26,24	67.00	34.54	65.65	
7440822		3.30	< 0.25	<	0.26	1.27	3.30	1.76	3.18	
7440005		0.39	< 0.10	۱.	0.10	0.20	0.30	Q.17	0.38	

Commente:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- Upper Limit exceeds the maximum concentration.

Notes:

- $\boldsymbol{\theta} = \textbf{Analyte}$ also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the feboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

3.3.4 Catalyst from Sulfur Complex and H₂S Removal Facilities (Tail Gas Treating Catalyst) - Residual 8

3.3.4.1 Description

SCOT®-like tail gas treating catalyst is generated in a manner similar to hydrotreating catalyst. The unit's purpose is to convert SO_2 to H_2S . Units generating SCOT®-like tail gas treating catalyst include the following:

- SCOT®-like units
- Beavon reactors (as part of a Stretford system or as part of an amine system)

A process flow diagram of the tail gas unit, which includes the hydroprocessing reactor, is included with the discussion of sulfur catalyst in Section 3.9. Unlike hydrotreating and hydrorefining catalysts, catalysts in SCOT®-like units are not exposed to metals in the feed. Therefore, the poisoning mechanisms for tail gas catalyst are limited to carbon deposition.

When catalyst activity is unacceptable, the reactor is taken out of service and undergoes one or more of the following steps to reduce the hydrocarbon content of the reactor:

- Nitrogen sweep (to remove naphtha)
- Hydrogen sweep (to burn residual hydrocarbon)
- Oxidation (to burn residual hydrocarbon)

The vast majority of refineries uses cobalt/molybdenum on alumina catalyst. Based on

Catalyst Pretreatment Steps Nitrogen sweep 29 facilities Hydrogen sweep 9 facilities Oxidation 22 facilities No preparation 6 facilities Other/unknown 6 facilities Source: 54 facilities reporting in situ treatment information from RCRA §3007 questionnaire.

a total of 69 SCOT®-like tail gas treating reactors reporting spent catalyst generation in the questionnaire, 93 percent reported using Co/Mo catalyst. An additional 6 percent reported using miscellaneous or unknown catalyst. This catalyst use profile is vastly different than other hydroprocessing applications where the usage of Ni/Mo and Co/Mo catalysts is roughly equal in the industry. Nickel catalyst is reported to be favored when denitrification reactions are desired (McKetta, 1992). Cobalt catalyst is likely to be used because only sulfur conversion is required for tail gas treating.

Approximately 83 MT of SCOT®-like catalyst generated in 1992 were identified as displaying hazardous characteristics. This is approximately 23 percent of the total quantity managed.

3.3.4.2 Generation and Management

The spent catalyst is vacuumed or gravity-dumped from the reactors. Based on information from site visits, most refineries place the material directly into closed containers such as 55-gallon drums or flobins. The RCRA §3007 questionnaire data support these observations.

1992 Identification of SCOT®-like Catalyst

D001 (Ignitable) 66 MT D003 (Reactive) 16 MT

Total identified as hazardous: 83 MT

Twenty-one facilities reported generating a total quantity of 361 MT of this residual in 1992, according to the 1992 RCRA \$3007 Questionnaire. Residuals were assigned to be "spent SCOT®-like catalyst" if they were assigned a residual identification code of "spent solid catalyst" or "solid catalyst fines" and were generated from a process identified as a SCOT® unit. These correspond to residual codes 03-A and 03-B, respectively, in Section VII.2 of the questionnaire and process code 15-D in Section IV-1.C of the questionnaire. Catalyst from other tail gas units, including Beavon-Stretford units, were not included in the statistics although the quantities of catalysts from the Beavon-Stretford units are similar to the quantities of catalyst generated from SCOT®-like units. Quality assurance was conducted by ensuring that all tail gas unit catalysts previously identified in the questionnaire (i.e., in Section V.B) were assigned in Section VII.2. Based on the results of the questionnaire, approximately 65 facilities have SO, conversion reactors as part of their tail gas system (as the "front end" to their SCOT[®], Stretford, or Selectox system) and thus likely generate spent tail gas hydroprocessing catalyst. Due to the infrequent generation of this residual, not all of these facilities generated spent catalyst in 1992. However, 1992 is expected to be a typical year in regard to catalyst change-out volume and management.

Table 3.3.15 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.3.15. Generation Statistics for Spent SCOT®-like Catalyst, 1992							
Final Management	# of Streams	# of Streams with unreported volume	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)		
Transfer metal catalyst for reclamation or regeneration	12	1	188	16	35 (estimate)		
Disposal offsite in Subtitle C landfill	5	0	103	21	63		
Disposal in offsite Subtitle D landfill	4	0	50	12	19		
Disposal in onsite Subtitle D landfill	1	0	10	10	10		
TOTAL	22	1	361	16	35		

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the existing and possible "high potential exposure" disposal practices currently used. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.3.15 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practice is:

Offsite Subtitle D landfilling (used for 14 percent of the total residual volume)

The input quantities for modeling releases using these scenarios were greater than those actually disposed in 1992. Instead, the management quantity is assumed to be the total quantity generated (minus that managed in Subtitle C units already). This is because other management methods, in particular reclamation, could change to landfilling in the future due to economic factors, convenience, or other factors. See Section 3.3.2.2 for additional details.

The management method accounting for the majority of the residual, transfer for offsite metals reclamation/regeneration, was not selected for modeling risks. A small number of catalyst reclaimers, such as CRI-MET in Louisiana and Gulf Metallurgical in Texas, reclaim spent catalyst for its vanadium, nickel, and molybdenum metal values. Both of these reclamation facilities routinely manage both characteristically hazardous and nonhazardous spent catalysts. One of these facilities segregates the hazardous and nonhazardous feedstocks, but following storage, both the hazardous and nonhazardous feeds are subjected to the same process. Therefore, risks from processing are equal for both characteristic and nonhazardous wastes.

A more detailed study of the catalyst recycling industry would be a significant endeavor, and was determined to be outside the scope of this listing determination. Based on the site visits described above, EPA believes that the practice of spent catalyst reclamation is valuable because it is consistent with the intent of RCRA and because, based on EPA's preliminary review of this industry, the spent catalysts appear to be managed and processed in a way that controls risks.

As with hydrotreating and hydrorefining catalysts, the Agency believed that it was unnecessary to model short-term interim storage used prior to final management. See the discussion for hydrotreating catalysts for details.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.3.16.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.3.17 provides a summary of the data for the targeted management practices used in the risk assessments for this residual. This table is developed using the RCRA §3007 survey of facilities reporting onsite landfilling of SCOT®-like catalyst

in any reported year. The survey specified that if the residual was not generated in 1992, to provide the information for the last year the residual was generated.

Table 3.3.16. Selection of Risk Assessment Modeling Scenario: Spent SCOT®-like Catalyst					
Final Management	Basis for Consideration in Risk Assessment				
Transfer metal catalyst for reclamation or regeneration	See discussion on previous page. Not modeled. Minimal volumes.				
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control				
Disposal in offsite Subtitle D landfill	Modeled				
Disposal in onsite Subtitle D landfill	Modeled				
Onsite storage ¹	Not modeled, not final management practice				

¹ Onsite storage indicates that the facility did not provide final management information.

3.3.4.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.3.18 summarizes the physical properties of the spent catalyst as reported in Section VII.A of the §3007 survey.
- Three record samples of spent SCOT®-like tail gas treating catalyst were collected and analyzed by EPA. These samples represent the spent catalyst generated throughout the industry and are summarized in Table 3.3.19.

Section 3.3.3.1 showed that there is essentially no process variation in the hydrotreating of tail gas. Essentially all catalyst is Co/Mo, and all treat sulfur recovery unit tail gas. Variations downstream of the unit, such as the type of treating solution used to remove H₂S, do not affect the spent catalyst generated in the hydroprocessing of this gas. Therefore, the sample set is expected to be representative of all tail gas catalyst generated.

All three samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. The high aluminum, molybdenum, and cobalt concentrations can be attributed to the catalyst make up: cobalt\molybdenum on alumina. A summary of the results is presented in Table 3.3.20. Only constituents detected in at least one sample are shown in this table.

Table 3.3.17. Management Practices Targeted for Risk Assessment							
Parameters	# of Fac.	# of RCs	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Onsite and Offsite Subtitle D Landfills ^{2,3}	4	5	0	60		12.7	26
All Management	_	18	2	257		9.3	35
Practices Except Subtitle C Landfills ¹			Onsite	Landfill Chara	cteristics		
	Surface A	Area (acres)		3.65	17	30
	Remainin	g Capacity	(cu.yd.)		62,800	450,400	838,000
	Percent F	Remaining	Capacity		2	5	7
	Total Cap	pacity (cu.)	/d.)		81,100	460,550	840,000
	Number	of Strata in	Completed Unit		0	0.5	1
	Depth Be	low Grade	(ft)		3	27	50
	Height A	bove Grad	c (ft)		o	4.5	9
	# of Lane	dfills: 2					
				Aquifer Informa	tion		
	Depth to	Aquifer (fl	:)		18	28.5	39
	Distance	to Private	Well (ft)		8,970	8,970	8,970
	Populatio	n Using P	rivate Well		No data	No data	No data
	Distance	to Public \	Well (ft)		58,000	58,000	58,000
	Populatio	n Using Pi	ıblic Well		1,500	1,500	1,500
	# of Aqu						
	Source: Public Private Unreported I 1 Uppermost 0 1 Lowermost I 0 Classification of Uppermost Aquifer: Not considered a potential source of drinking water (2)						

¹ The number of onsite landfills characterized in Table 3.3.17 is greater than indicated in Table 3.3.15, which focuses only on volumes generated in 1992. Table 3.3.17 incorporates data from all onsite landfills receiving spent catalyst in any year reported in the §3007 survey.

² Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

³ The mean and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream from one refinery may be disposed of in one management unit causing the 90th percentile number actually to be the sum of 2 or 3 waste volumes).

Table 3.3.18. SCOT®-like Catalyst Physical Properties							
Properties	# of Values	# of Unreported Values	10th %	Mean	90th %		
pH	17	51	3.8	4.5	5.7		
Reactive CN, ppm	13	55	0	24	20		
Reactive S, ppm	21	47	1.0	38	112		
Flash Point, C	12	56	60	84	100		
Oil and Grease, vol%	9	56	0	0.3	1.0		
Total Organic Carbon, vol%	10	57	0	0.6	2.5		
Specific Gravity	18	50	0.7	1.75	2.56		
BTU Content, BTU/lb	5	63	0	1,200	3,000		
Aqueous Liquid, %	36	32	0	2.9	1.0		
Organic Liquid, %	36	32	0	0.4	1.0		
Solid, %	49	19	97.5	97	100		
Particle > 60 mm, %	20	48	0	15	100		
Particle 1-60 mm, %	27	41	0	85	100		
Particle 100 μm-1 mm, %	22	46	0	5.0	1.0		
Particle 10-100 μm, %	18	5 0	0	0	0		
Particle < 10 μm, %	18	50	0.5	0	0		
Mean Particle diameter, microns	7	59	0	2500	7,000		

Table 3.3.19. SCOT [®] -like Catalyst Record Sampling Locations							
Sample number	Facility	Description: Catalyst					
R5-SC-02	Marathon, Garyville, LA	Co/Mo catalyst					
R7B-SC-01	BP, Belle Chasse, LA	Co/Mo catalyst					
R11-SC-01	ARCO, Ferndale, WA	Co/Mo catalyst					

3.3.4.4 Source Reduction

All source reduction efforts and limitations tabulated for hydrotreating catalyst (Section 3.3.2.4) are applicable for tail gas hydroprocessing catalyst.

In addition, some tail gas treating processes, such as the Stretford process, do not use solid catalyst and do not generate this residual. In the Stretford process, the catalyst is in a liquid state and is continuously reused. Stretford systems have limited use as tail gas units. Note that although the solid catalyst stream is eliminated in the Stretford process, the possibility of the liquid catalyst being present in other waste or residual streams was not investigated.

None of the samples exhibited any hazardous waste characteristics (i.e., no constituents in the samples' TCLP extracts exceeded the corresponding regulatory level, and no other characteristics of ignitability, corrosivity, or reactivity were found).

Table 3.3.20. Residual Characterization Data for Spent SCOT®-like Catalyst

									100 C-4:	
	Volatila Organica	- Meth	n 4 8280	A un/ka				•	10% Confidence Interval	
	CAS No.			R7B-\$C-01	B11-SC+01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
Benzene	71432			< 625			801	30	117	1.2
n - Butyibenzene	104518		5				700	396	674	
Trichkrofluoromethane	75894		29	< 625	< 25		29	3	ادد	1, 2
Toluene	108883	<	5.	< 625	J 24		. 24	13	44	1.2
1.2.4 — Trimethylbenzene	95636	<	5	7,500			- 1	4,321	7,218	•,•
1,3,6 — Trimethylbenzene	108678	~	5	3.300	1		3,300	1,891	3,176	
• •	95476	1 "	8	J 1,040		1,00	1,040	592	1.001	
o - Xylena	108383 / 108423	ŧ	5	2,500			2,500	1,424	2,407	
mp-Xylenes	108101	12	5	< 625	250		2,500	173	505	1, 2
4-Mathyl-2-pentanone	78933	1		< 825	1		460	322	933	1, 2
Mathyl ethyl kelone	75092	2	_	< 625				39	117	-
Mathylene chloride	75002	1 <	•	020	1 60	, 33	00	391	117	1, 2
	TCLP Volatile Or	aunica -	- Matho	ds 1311 and 826	lou AO			ı	90% Confidence Interval	
	CAS No.			R7B-SC-01		Average Core	Meximum Conc	Std Dev	Upper Limit	Comments
64.46.45.ca. abbedda	75092		50 - 32 50		B 1.600			895	1,541	Commence
Methylene chloride	75002	1 -	•	, ~	, 5 1,000	, 501	1,000	000;	1,547	
									90% Confidence	
	Semirolatile Org				B44 BB			0145	interval	
	CAS No.		_	P78-SC-01	•		Maximum Conc	Std Dev	Upper Limit	Comments
Bis (2 — ethythexyl) phthalate	117817	•	165		J 300		300	107	301	2
Di-n-butyi phthelete	84742	J	90	J 120	J 120	110	120	17	120	2
	f									
	TCLP Semivolati								90% Confidence Interval	•
	CAS No.	R5-	SC-02	R78-80-01	R11-8C-01		Maximum Cone	Std Dev	interval Upper Limit	Comments
Bis (2—ethythexyl)phthalate	CAS No. 117817	R5-	SC-02 540	R7B-SC-01 < 50	R11-8C-01 JB 35	208	540	Std Dev 287	interval Upper Limit 521	
Di-n-butyl phthalate	CAS No. 117817 84742	R5-	SC-62 540 50	R78-80-01 < 50 < 50	R11 - SC - 01 JB 35 J 31	208 31	540 31	Std Dev 287 NA	interval Upper Limit 521 NA	Comments
	CAS No. 117817	R5-	SC-02 540	R78-80-01 < 50 < 50	R11 - SC - 01 JB 35 J 31	208 31	540	Std Dev 287	interval Upper Limit 521	
Di-n-butyl phthalate	CAS No. 117817 84742	R5-	SC-62 540 50	R78-80-01 < 50 < 50	R11 - SC - 01 JB 35 J 31	208 31	540 31	Std Dev 287 NA 81	interval Upper Limit 521 NA	
Di-n-butyl phthalate	CAS No. 117817 84742 110661	R5-	- SC - 62 540 50 100	R78−8C-01 < 50 < 50 240	R11-8C-01 JB 35 J 31 < 100	208 31 147	540 31	Std Dev 287 NA 81	interval Upper Limit 521 NA 235	
Di-n-butyl phthalate	CAS No. 117817 84742 110661	R5-	SC -62 540 50 100	R7B - SC - 01 < 50 < 50 240 060, 7421,7470,	R11 - 8C - 01 JB 35 J 31 < 100 7471, and 7841 s	208 31 147	540 31 240	Std Dev 287 NA 81	Interval Upper Limit 521 NA 235	1
Di-n-butyl phthalate Pylidine	CAS No. 117817 84742 110861 Total Metals N CAS No.	R5-	SC -62 540 50 100 6010, 70 SC -02	R78-SC-01 < 50 < 50 240 160, 7421, 7470, R78-SC-01	R11-8C-01 JB 35 J 31 < 100 7471, and 7841 ; R11-8C-01	208 31 147 mg/kg Average Conc	540 31	Std Dev 287 NA 81	interval Upper Limit 521 NA 235 90% Confidence Interval	
Di-n-butyl phthalate Pylidine Aluminum	CAS No. 117817 84742 110861 Total Metals — N CAS No. 7429905	R5-	- SC - 62 540 50 100 8010, 70 - SC - 02 200,000	R78-SC-01 < 50 < 50 240 160, 7421, 7470, R78-SC-01 360,000	R11-8C-01 JB 35 J 31 < 100 7471, and 7841; R11-8C-01	208 31 147 ng/kg Average Conc 223,333.3	540 31 240 Maximum Conc 360,000.0	Std Dev 287 NA 81 Std Dev	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit	1 Commenta
Di-n-butyl phthalate Pylidine Aluminum Artimony	CAS No. 117817 84742 110861 Total Metals — N CAS No. 7429905 7440380	R5-	80 10, 70 80 100 140 14.0	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 20.0	R11-8C-01 JB 35 J 31 < 100 7471, and 7841; R11-8C-01 110,000 < 6.0	208 31 147 mg/kg Average Conc 223,333.3 13.3	540 31 240 Maximum Cone 380,000.0	Std Dev 287 NA 81 Std Dev 126,622.8	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,219.7	1 Commenta 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic	CAS No. 117817 84742 110661 Total Metals — N CAS No. 7429005 7440360 7440382	RS-	8C - 62 540 50 100 8010, 70 9C - 02 200,000 14.0 10.0	R78 - SC-01 < 50 < 50 240 860, 7421, 7470, R78 - SC-01 360,000 20.0	R11-SC-01 JB 35 J 31 < 100 7471, and 7841; R11-SC-01 110,000 < 6.0 28.0	208 31 147 ng/kg Average Conc 223,333.3 19.3	540 31 240 Maximum Conc 380,000.0 20.0 28.0	Std Dev 287 NA 81 Std Dev 128,622.8 7.0	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2	1 Comments 2 2 2
Di-n-butyl phthalale Pylicline Aluminum Artimony Arsenic Beryllium	CAS No. 117817 84742 110661 Total Metals — N CAS No. 742905 7440382 7440417	R5-	SC-62 540 60 100 6010,70 SC-02 200,000 14.0 0.5	R78-SC-01 < 50 < 50 240 60, 7421,7470, R78-SC-01 360,000 < 20.0 < 20.0	R11-8C-01 JB 35 J 31 < 100 7471, and 7841; R11-8C-01 110,000 < 6.0 28.0 < 0.5	208 31 147 ng/kg Average Conc 223,333.3 19.3 19.3	540 31 240 Maximum Cone 380,000.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,219.7	1 Comments 2 2 2
Di-n-butyl phthalate Pyticline Aluminum Artimony Arsenic Beryllium Cadmium	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440417	RS-	SC-62 540 60 100 6010, 70 -SC-02 200,000 14.0 0.5 6.5	R78-SC-01 < 50 < 50 240 60, 7421,7470, R78-SC-01 360,000 < 20,0 < 20,0 9,4	R11-8C-01 JB 35 J 31 < 100 7471, and 7841 r R11-8C-01 110,000 < 6.0 < 0.5 5.7	208 31 147 ng/kg Average Cond 223,333.3 19.3 19.3 7.2	540 31 240 Maximum Cone 380,000.0 20.0 28.0 2.9 9.4	Std Dev 287 NA 81 Std Dev 125,622.8 7.0 9.0 1.4	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3	1 Comments 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadesium Chromium	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440473	Ris –	- SC - 62 540 50 100 6010, 70 - SC - 02 200,000 14.0 0.5 6.3 6.3	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 20.0 < 20.0 9.4 13.0	R11-SC-01 JB 35 J 31 < 100 7471, and 7841 r R11-SC-01 110,000 < 6.0 28.0 < 0.5 5.7 4.8	208 31 147 ng/kg Average Cond 223,333,3 19,3 19,3 7,2 8,0	540 31 240 Maximum Conc 380,000.0 20.0 28.0 2.9 9.4 13.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3 12.8	1 Commenta 2 2
Di-n-butyl phthalate Pyticline Aluminum Artimony Arsenic Beryllium Cadmium Chromium Cobait	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440417 7440439 7440473 7440484	Ris –	SC-62 540 50 100 6010, 70 -SC-02 200,000 14.0 0.5 63 62	R78-SC-01 < 50 < 50 240 860, 7421, 7470, R78-SC-01 360,000 20.0 < 20.0 4 13.0 19,000.0	R11-SC-01 JB 35 J 31 < 100 7471, and 7841 r R11-SC-01 110,000 < 6.0 28.0 < 0.5 5.7 4.8 11,000,0	208 31 147 ng/kg Average Conc 223,333,3 193, 1,3 7,2 8,0 14,333,3	540 31 240 Maximum Conc 380,000.0 20.0 28.0 2.9 9.4 13.0 19,000.0	Std Dev 287 NA 81 Std Dev 28,622.8 7.0 9.0 1.4 1.9 4.4 4,163.3	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361;210.7 21.0 29.2 2.8 9.3 12.8 18,885.7	Comments 2 2 2
Di-n-butyl phthalate Pyticline Aluminum Artimony Arsenic Beryllium Cadellum Chromium Cobait Copper	CAS No. 117817 84742 110861 Total Metals N CAS No. 7429905 7440380 7440382 7440437 7440484 7440508	RS –	8010,70 8010,70 90-92 200,000 14.0 10.0 65 62 3,000.0	R78-SC-01 < 50 < 50 240 860, 7421, 7470, R78-SC-01 363,000 20.0 < 20.0 2.9 9.4 13.0 19,000.0 33.0	R11-SC-01 JB 35 J 31 < 100 7471, and 7841; R11-SC-01 110,000 < 6.0 28.0 < 0.5 5.7 4.8 11,000.0	208 31 147 ng/kg Average Core 223,333,3 19,3 1,3 7,2 8,0 14,333,3 25,3	540 31: 240 Maximum Conc 360,000.0 20.0 28.0 2.9 9.4 13.0 19,000.0	Std Dev 287 NA 81 Std Dev 28,622.8 7.0 9.0 1.4 1.9 4.4 4,163.3	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,219.7 21.0 29.2 2.8 9.3 12.8 18,866.7 30.2	Comments 2 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Antimony Arsenic Beryllium Cadmium Chromium Chosit Copper	CAS No. 117817 84742 110661 Total Metals — N. CAS No. 7429005 7440380 7440439 7440439 744049 744049 7440508 7439896	RS –	80-02 540 59 100 6010, 70 9C-02 200,000 140 0.5 6.5 6.2 13,000,0 1,700,0	R7B - SC-01 < 50 < 50 240 60, 7421, 7470, R7B - SC-01 360,000 20.0 < 20.0 19,000 19,000 3,500.0 3,500.0	R11-SC-01 JB 35 J 31 < 100 7471, and 7841 of R11-SC-01 110,000 < 6.0 28.0 < 0.5 5.7 4.1 11,000.0 12,000	208 31 147 ng/kg Average Cone 223,333,3 19,3 7,2 8,0 14,333,3 25,3 1,810,0	540 31: 240 Maximum Conc 360,000.0 20.0 28.0 2.9 9.4 13.0 19,000.0 33.0 3,500.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4 4.163.3 10.0 1,637.8	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3 12.8 18,865.7 36.2 3,593.3	Comments 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadenium Chromium Cobatt Copper kon Manganese	CAS No. 117817 84742 110661 Total Metals — N CAS No. 742905 7440382 7440417 7440439 7440473 7440484 7440506 7439905	RS –	- SC - 62 540 59 100 6010, 70 - 9C - 02 200,000 140,0 0.5 6.5 6.2 13,000.0 290,0 1,700.0 3.2	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 < 20.0 < 20.0 < 29.0 9.4 13.0 19,000.0 3,500.0 54.0	R11-8C-01 JB 35 J 31 < 100 7471, and 7841; R11-8C-01 110,000 < 6.0 28.0 < 0.5 5.7 4.8 11,000.0 14.0 230.0 < 1.5	208 31 147 ng/kg Average Conc 223,333.3 19.3 1.3 7.2 8.0 14,333.3 253.3 1,810.0	540 31 240 Maximum Cone 380,000.0 28.0 2.9 9.4 13.0 19,000.0 33,500.0 54.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4 4,163.3 10.0 1,637.8 20.8	Interval Upper Limit	Commenta 2 2 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadesium Chromium Cobett Copper Iron Manganese Molybdenum	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440417 7440439 7440484 7440508 7439805 7439876	RS-	- SC - 62 540 59 100 6010, 70 - SC - 02 200,000 14.0 0.5 6.3 6.2 (3,000.0 1,700.0 3.2 (8,000.0	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 < 20,0 < 20,0 4, 13,0 19,000,0 33,0 9,500,0 54,000,0	R11-8C-01 JB 35 J 31 < 100 7471, and 7841; R11-9C-01 110,000 < 0.0 28.0 < 0.5 5.7 4.8 11,000.0 14.0 230.0 < 1.5 25,000.0	208 31 147 ng/kg Average Cond 223,333.3 19.3 7.2 8.0 14,333.3 25.3 1,810.0 19.5 42,333.3	540 31 240 Maximum Conc 380,000.0 28.0 28.0 2.9 9.4 13.0 19,000.0 33.0 3,500.0 54.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4 4.163.3 10.0 1,637.8 29.8 15,308.0	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3 12.8 18.865.7 35.2 3,593.3 52.1 59,001.9	Commenta 2 2 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadenium Chromium Cobait Copper Iron Manganese Molybdenum Nickel	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440473 7440494 7440508 7439965 7439965 7439067	RS-	- SC - 62 540 50 100 6010, 70 - SC - 02 200,000 140 0.5 6.5 6.2 13,000.0 29.0 1,700.0 3.2 18,000.0 120.0	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 20.0 < 20.0 2.9 9.4 13.0 19,000.0 33.0 3,500.0 54,000.0 73.0	R11-8C-01 JB 35 J 31 < 100 7471, and 7841 r R11-8C-01 110,000 < 0.0 28.0 < 0.5 5.7 4.8 11,000.0 14.0 230.0 < 1.5 25,000.0 18.0	208 31 147 ng/kg Average Conc 223,333,3 193,3 1,3 7,2 8,0 14,333,3 25,3 1,810,0 19,5 42,333,3 70,3	540 31 240 Maximum Conc 380,000.0 28.0 2.9 9.4 13.0 19,000.0 33.0 3,500.0 54.0 54.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4 4,163.3 10.0 1,637.8 29.8 15,308.0	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3 12.8 18,865.7 35.2 3,593.3 52.1 59,001.9 125.9	Commenta 2 2 2 2 2 2 2 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadmium Chromium Cobait Copper Iron Manganese Molybdenum Nickel Selenium	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440473 7440494 7440508 7439965 7439965 7430905 7440020 7782492	RS –	8C-62 540 59 100 8010, 70 9C-02 200,000 140 100 65 62 13,000.0 29 0 1,700.0 3 2 18,000.0 22.0	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 20.0 < 20.0 4 13.0 19,000.0 33.0 3,500.0 54,00.0 73.0 < 2.5	R11-8C-01 JB 35 J 31 < 100 7471, and 7841 r R11-8C-01 110,000 < 6.0 28.0 < 0.5 5.7 4.8 11,000.0 14.0 230.0 < 25,000.0 18.0 < 0.5	208 31 147 ng/kg Average Cond 223,333,3 19,3 1,3 7,2 8,0 14,333,3 25,3 1,510,0 19,5 42,333,3 70,3	540 31 240 Maximum Conc 380,000.0 20.0 28.0 2.9 9.4 13.0 19,000.0 33.00 350.0 54.0 54.0 120.0	Std Dev 287 NA 81 Std Dev 26,622.8 7.0 9.0 1.4 1.9 4.4 4.163.3 10.0 1,637.8 29.8 15,308.0 51.1	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,219.7 21.0 29.2 2.8 9.3 12.8 18,865.7 30.2 3,593.9 52.1 59,001.9 125.9 4.0	Comments 2 2 2 2 2 2 2 2 1, 2
Di-n-butyl phthalate Pytidine Aluminum Artimony Arsenic Beryllium Cadenium Chromium Cobait Copper Iron Manganese Molybdenum Nickel	CAS No. 117817 84742 110861 Total Metals — N CAS No. 742905 7440380 7440382 7440473 7440494 7440508 7439965 7439965 7439067	RS –	- SC - 62 540 50 100 6010, 70 - SC - 02 200,000 140 0.5 6.5 6.2 13,000.0 29.0 1,700.0 3.2 18,000.0 120.0	R78-SC-01 < 50 < 50 240 60, 7421, 7470, R78-SC-01 360,000 20.0 < 20.0 4 13.0 19,000.0 33.0 3,500.0 54,00.0 73.0 < 2.5	R11-SC-01 JB 35 J 31 < 100 7471, and 7841; R11-SC-01 110,000 < 6.0 28.0 < 0.5 5.7 4.1 11,000.0 < 1.5 25,000.0 < 0.5 2,500.0	208 31 147 ng/kg Average Cond 223,333,3 19,3 1,7,2 8,0 14,333,3 25,3 1,810,0 19,5 42,330,3 70,3 1,4	540 31 240 Maximum Conc 380,000.0 20.0 28.0 2.9 9.4 13.0 19,000.0 33.0 3,500.0 54,000.0 120.0 2.2 2,500.0	Std Dev 287 NA 81 Std Dev 126,622.8 7.0 9.0 1.4 1.9 4.4 4,163.3 10.0 1,637.8 29.8 15,308.0	Interval Upper Limit 521 NA 235 90% Confidence Interval Upper Limit 361,210.7 21.0 29.2 2.8 9.3 12.8 18,865.7 35.2 3,593.3 52.1 59,001.9 125.9	Commenta 2 2 2 2 2 2 2 2

SCOT CATALYST from SULFUR COMPLEX

								90% Confidence			
	TCLP Metals M	TCLP Metals Methods 1311, 6010, 7080, 7421, 7470, 7471, and 7841 mg/L							interval		
	CAS No.	R5-SC-02	R78-SC-01	R11-SC-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Commente		
Aluminum	7429905	17.00	32.00	22.00	23.67	32.00	7.84	31.98			
Cadmium	7440439	< 0.03	0.20	< 0.03	0.08	0.20	0.10	0.19			
Chromium	7440473	< 0.05	0.13	< 0.05	0.08	0.13	0.05	0.13			
Cobait	7440484	66.00	480,00	220.00	248.67	480.00	198.58	464.87			
tron	7439896	6.30	< 0.50	< 0.50	2.43	6.30	3.35	6.08			
Manganese	7439965	D.34	0.99	< 0.08	0.47	0.99	0.47	0.98			
Molybdenum	7439987	39.00	480.00	430.00	316.33	480.00	241.48	579.27	2		
Nickal	7440020	0.58	0.54	< 0.20	0.44	0.58	0.21	0.87	2		
Vanadium	7440822	< 0.25	1.00	1.40	1.18	1.90	0.85	2.10			

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Upper Limit exceeds the maximum concentration.

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

3.4 REFORMING

3.4.1 Process Description

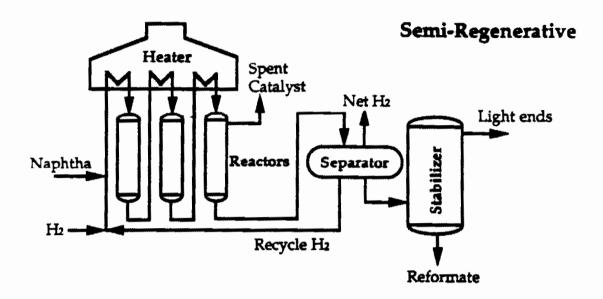
Catalytic reforming is used to upgrade (increase the octane of) naphtha for use as motor gasoline. Two types of reactions occur during the reforming step: (1) dehydrogenation of cycloparaffins to form aromatics, and (2) cyclization and dehydrogenation of straight chain aliphatics to form aromatics. In a reforming unit, several (typically 3 to 5) reactor vessels are placed in series interspersed with heaters. Catalyst is present in the reactor vessels and always contains platinum and in most cases, according to *Oil and Gas Journal*, is bimetallic (e.g., platinum/rhenium). Because the reaction is endothermic, heaters are required to maintain reaction conditions of approximately 150 psi and 500 to 1,000 °F (McKetta, 1992). Fractionators are used to separate the product reformate from light ends such as hydrogen, a reaction byproduct.

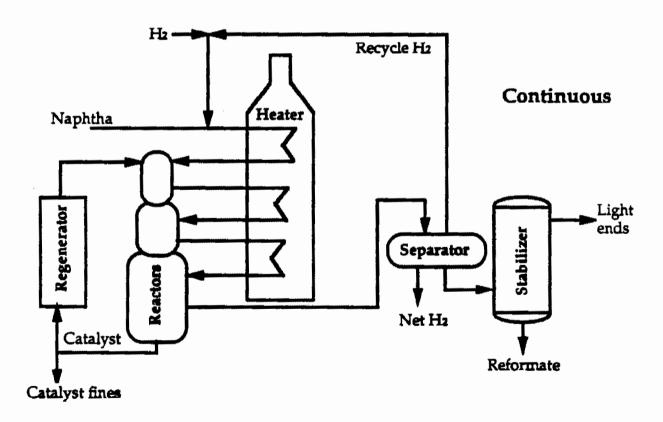
An important feed preparation step, hydrotreating, is not shown on the diagram. Sulfur is a reformer catalyst poison and for this reason the feed is desulfurized prior to entering the reformer beds; this catalyst is not considered reforming catalyst but is instead hydrodesulfurization (i.e., hydrotreating, see Section 3.3.1) catalyst.

Reforming unit operations are of three types: (1) semiregenerative, (2) cyclic, and (3) continuous, the principal difference being the period of time between catalyst regeneration. A semiregenerative unit consists of a series of reactors containing a fixed bed of catalyst. The unit typically operates for approximately 12 to 18 months before the unit is taken off-line for regeneration, when all reactors are regenerated at once and no product is generated. A cyclic unit also consists of a series of fixed bed reactors; one reactor is off-line at any one time for regeneration. In this way, the unit is always generating product from the three or four operating reactors. In a continuous unit, the catalyst continuously moves through the reactors at a slow rate, with regeneration in a (closed loop) parallel unit. According to RCRA §3007 data, 135 facilities have reformers. Sixty percent of the facilities have semiregenerative units, 25 percent have cyclic units, and 30 percent have continuous units. The summed percentages exceed 100 percent because some facilities have multiple units.

For all three cases, regeneration typically consists of (1) nitrogen purge, (2) oxygen burn, (3) addition of a chlorine source (such as a chlorinated hydrocarbon, hydrogen chloride, or elemental chlorine), and (4) nitrogen purge. The first nitrogen purge is used to remove free hydrocarbons from the reactor. The second step, addition of oxygen, burns off the built-up coke from the catalyst pellets. The third step, chlorination, is done to redistribute the platinum chloride on the alumina substrate to reactivate the catalyst following the oxygen burn. Some facilities may add a sulfur-containing compound after chlorination to passivate the catalyst somewhat. The final nitrogen purge is performed to prepare the catalyst bed for service. Figure 3.4.1 presents simplified diagrams of a semiregenerative and continuous process. The cyclic process closely resembles the semiregenerative process shown in this figure.

Figure 3.4.1. Process Flow Diagram for Catalytic Reforming





3.4.2 Reforming Catalyst - Residual 9

3.4.2.1 Description

Regeneration of a fixed catalyst bed can be performed only a limited number of times before the catalyst loses its activity. Complete removal of the catalyst and replacement with fresh catalyst occurs infrequently, such as every 5 to 10 years. To prepare the catalyst prior to dumping, the reactor may undergo one of the following steps to reduce the hydrocarbon content of the reactor:

- Nitrogen sweep (to remove naphtha)
- Hydrogen sweep (to burn residual hydrocarbon)
- Oxidation (to burn residual hydrocarbon)
- Steam stripping (to remove volatiles)

Following removal, the catalyst may be shipped offsite in closed containers as spent catalyst. Alternatively, some facilities screen and replace the catalyst. This technique removes small particles of coke and catalyst. According to the RCRA §3007 questionnaire data, 5 facilities report

Catalyst Pretreatment Steps

Nitrogen sweep	73 facilities
Hydrogen sweep	64 facilities
Oxidation	61 facilities
No preparation	12 facilities
Steam stripping/	8 facilities
other/unknown	

Source: 109 facilities reporting in situ treatment information from RCRA §3007 questionnaire.

this practice. Based on site visit information, this practice occurs more frequently than complete change-out (e.g., every 1 to 4 years). The purpose of screening is to prolong catalyst life and improve unit operation.

In the operation of the continuous catalytic reformer, catalyst fines are generated continuously and are typically removed prior to the regeneration step. Fines are generated from the movement of catalyst in the system. Following the reaction step, the catalyst must be blown to the top of the regenerator. Fines are collected because they are undesirable to the process.

In summary, residual reforming catalyst is generated primarily from three operations, in increasing order of generation frequency: (1) complete changeout of the catalyst (applicable for all three units); (2) periodic "dump and screen"

1992 Identification of Reforming Catalyst

D018 (TC benzene) 419 MT D003 (Reactive) 151 MT D001 (Ignitable) 143 MT D004 (TC Arsenic) 16 MT

Total identified as hazardous: 459 MT (some streams carry multiple codes)

(applicable for only the cyclic and semiregenerative units); and (3) continual generation of fines (applicable only for the continuous unit).

Approximately 459 MT of reforming catalyst generated in 1992 were identified as displaying hazardous characteristics. This is approximately 13 percent of the total volume managed.

3.4.2.2 Generation and Management

Based on the RCRA §3007 questionnaire and observations from 6 sampling events, catalyst is predominantly collected and stored in closed containers such as drums or flobins. This practice is conducted to minimize losses of this highly valuable residual.

Fifty-eight facilities reported generating a total quantity of 3,613 MT of this residual in 1992, according to the 1992 RCRA §3007 Questionnaire. Residuals were assigned to be "spent reforming catalyst" if they were assigned a residual identification code of "spent solid catalyst" or "solid catalyst fines" and were generated from a process identified as a reforming unit. These correspond to residual codes 03-A and 03-B, respectively, in Section VII.2 of the questionnaire and process code 08 in Section IV-1.C of the questionnaire. Quality assurance was conducted by ensuring that all reforming catalysts previously identified in the questionnaire (i.e., in Section V.B) were assigned in Section VII.2. Based on the results of the questionnaire, 135 facilities use reforming units and thus likely generate spent reforming catalyst. Due to the infrequent generation of this residual, not all of these facilities generated spent catalyst in 1992. However, 1992 is expected to be a typical year in regard to catalyst change-out volume and management. Table 3.4.1 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

No plausible management scenario was selected by EPA to perform a risk assessment model. The predominant management method, offsite reclamation, was not modeled because of the absence of significant exposure pathways from the reclamation process. A more detailed study of the precious metals reclamation industry would be a significant endeavor, and was determined to be outside the scope of this listing determination. The predominant storage method, closed container, was not modeled because no releases or exposures are expected from a closed container.

No other management practice was assumed to be reasonable for this material. Based on facility estimates, the platinum value in the spent catalyst is roughly \$25,000 to \$50,000 per metric ton. In short, the residual is too valuable to be disposed or mishandled. In regard to other residuals generated during turnaround operation, such as support balls and fines that are not necessarily sent offsite for reclamation, these residuals are much smaller in volume (e.g., de minimis volumes) than their "parent" residuals and thus were not evaluated further.

Table 3.4.1. Generation Statistics for Spent Reforming Catalyst, 1992							
Final Management	# of Streams	# of with unreported volume	Total Volume (MT)	Average Volume (MT)	90th % Volume (MT)		
Transfer metal catalyst for reclamation or regeneration	91	6	3,275	36	92 (estimate)		
Offsite cement plant ¹	1	0	180	180	180		
Onsite recycle ²	7	1	90	13	64.3		
Disposal in onsite wastewater treatment plant	1	0	45	45	45		
Offsite reuse	1	0	20	20	20		
Onsite storage ³	1	0	1.4	1.4	1.4		
Disposal in onsite Subtitle D landfill	1	0	0.5	0,5	0.5		
Disposal offsite in Subtitle D landfill	1	0	0.2	0.2	0.2		
Other ³	0	4	0	0	0		
TOTAL	104	11	3,613	35	89		

¹ These management methods reflect residuals derived from reforming catalyst: one facility generates crushed support balls from screening operations for disposal in an onsite landfill; one facility generates support balls from screening operations for offsite reuse at a cement plant; one facility generates wastewater from regeneration which is discharged to their wastewater treatment process.

3.4.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.4.2 summarizes the physical properties of the reforming catalyst as reported in Section VII.A of the §3007 survey.
- Six record samples of actual reforming catalyst were collected and analyzed by EPA. These spent catalysts represent the various types of generating processes used by the industry and are summarized in Table 3.4.3.

² Onsite recycle includes reuse in same or similar unit, reuse as catalyst support, and onsite regeneration.

³ Final, ultimate management was not provided for this residual following storage.

⁴ This management method reflects a catalyst residual generated from a screening operation. These fines, containing platinum catalyst, coke, and support material, were disposed in an offsite landfill because the platinum value is too low for economic recovery.

⁵ Other interim management practices were included, with no effect on total volume, 90th percentile, or mean volume.

Table 3.4.2. Spent Reforming Catalyst Physical Properties						
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %	
pН	62	220	3.7	5.3	8	
Reactive CN, ppm	36	246	0.1	9.6	10	
Reactive S, ppm	46	236	0.5	75	500	
Flash Point, C	48	234	0	83	200	
Oil and Grease, vol%	47	235	0	1.0	1.0	
Total Organic Carbon, vol%	41	241	0	1.4	5.5	
Specific Gravity	57	225	0.51	2.6	2.6	
BTU Content, BTU/lb	17	265	0	88	500	
Aqueous Liquid, %	108	174	0	2.4	0	
Organic Liquid, %	109	173	0	1.3	0.1	
Solid, %	196	86	100	98	100	
Particle > 60 mm, %	37	245	0	19	100	
Particle 1-60 mm, %	88	194	50	87	100	
Particle 100 μm-1 mm, %	66	216	0	12.5	50	
Particle 10-100 μm, %	34	248	0	3.1	0	
Particle < 10 μm, %	32	250	0	0.2	0	
Mean Particle diameter, microns	23	257	0	2,100	2,720	

Two samples of catalyst fines were collected from continuous catalytic reforming units, while the remaining four samples were collected from the "dumping" of fixed bed reactors (two samples were catalyst collected from cyclic units, and two samples were catalyst collected from semi-regenerative units). As discussed in Section 3.4.1, these units represent all of the catalytic reforming units. Each of the three units is common in the industry. Both platinum and bimetallic catalyst were collected, representing the two principal types of catalysts in use. No samples of fines collected from screened catalyst were collected. However, this is a low-volume stream in comparison to the reactor samples collected. These fines also contain many of the same constituents (i.e., platinum catalyst) and are often managed in the same way (i.e., offsite reclamation).

Table 3.4.3. Reforming Catalyst Record Sampling Locations						
Sample number	Facility	Description: Type of Generating Unit, Catalyst				
R2-CR-01	Shell, Wood River, IL	Cyclic unit, platinum catalyst				
R5-CR-01	Marathon, Garyville, LA	Continuous unit, platinum catalyst fines				
R7B-CR-01	BP, Belle Chasse, LA	Semi-regenerative unit, platinum/rhenium catalyst				
R11-CR-01	ARCO, Ferndale, WA	Semi-regenerative unit, platinum/rhenium catalyst				
R14-CR-01	BP, Toledo, OH	Cyclic unit, platinum catalyst				
R15-CR-01	Total, Ardmore, OK	Continuous unit, platinum/tin catalyst fines				

All six samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. All samples were also analyzed for total dioxin/furans. One of the six samples analyzed displayed the TC characteristic for benzene (i.e., benzene levels in the TCLP extract were found above 0.5 mg/L). No other hazardous characteristics were displayed in any other samples. High aluminum concentrations can be attributed to the catalyst make up of platinum on alumina. A maximum concentration of 9.9 ng/kg (2,3,7,8-TCDD equivalence) was found in one sample. Dioxin is known to form in the reforming regeneration sequence, where chlorine is used as part of catalyst regeneration.³ A summary of the results is presented in Table 3.4.4. Only constituents detected in at least one sample are shown in this table.

³ EPA's Office of Water is investigating dioxin formation in reformers. For more information refer to the document Petroleum Refining Industry - Presence of Dioxins and Furans in Wastewater Generated by Reforming Operations. Ron Kirby, US EPA Office of Water, Engineering and Analysis Division, Energy Branch. May 1994.

Table 3.4.4. Residual Characterization Data for Spent Reforming Catalyst

											90% Confidence	
	Volatile Organics									·	Interval	-
<u>_</u>	CAS No.	R2-CR-01	R5-CR-01	R78-CR-01	R19-CR-01	R14-CR-01	A15-CR-01	Average Cons	Maximum Cono	Sid Dav	Upper Limit	Comments
Benzene	71412	< 25		2,300	430	570	26,000		26,000	10,291	11,255	
n-Bulyibenzene	104518	< 25	57,000	220	< 25	< 22	8,900		57,000	22,795	24,768	
rec-Butylbenzene	135918	< 25	J 23,000	110	< 25	< 22	2,400		23,000	9,227	0,824	
Ethylbenzene	100414	< 25	51,000 J 23,000	1,000	< 25	620	26,000	1	51,000	21,099	25,975	
2-Hexanone	591756	< 25			< 25		< 525		23,000	9,334	0,578	
Isopropyibenzene	98626	< 25	27,000	180	< 25	46	5,700		27,000	10,773	11,986	
n-Propylbenzene	103651	< 25	60,000	570	< 25		< 625	,	60,000	24,388	24,917	
Toluens	108633 95636	< 25 2,800	23,000	11,000 4,000	610	6,100	37,000		37,000	14,320	21,918	
1,2,4—TrimeSyleenzene 1,3,5—TrimeSyleenzens	108876	2,800 580	\$10,000 91,000	4,000 590	< 25 < 25	390 160	23,000		310,000	124,385	131,556	
o-Xviens	95476	110	110,000	5,100	< 25	720	20,000 49,000		91,000 110,000	36,271 44,705	40,582 54,430	
m.pXylanes	106383 / 108423	220	170,000	9.000	< 25	4,500	69,000		170,000	87.P94	83,095	
Methyl ethyl ketone	78933	< 25	< 625	260	< 25	95	3,200	- 1	3,200	1,243	1,454	
Methylene chloride	75092	< 25	< 525	< 25	56		< 625		55	18	44	1
Naphthelene	91203	1,900		430	< 25				9,500	3,598	4.012	•
	1.5.01	,,,,,,,				,	0,000	2,00	5,0001	D, GEO I	7,0121	
)							
	L			_						•	90% Contidence	9
	TCLP Volatile Org				D						Interval	_
B	CAS No.	R2-CR-01	R5-CR-01	R78-CR-01		R14-CR-01			Maximum Conc	Std Dev	Upper Limit	Comments
Benzens	71432	< 60	3,000			< 50	NA		3,000	1,316	1,548	
Ethylbenzane Tokuene	108833	< 50 < 50	470 4,000	J 59 440	J 29 250	< 50 300	MA NA		470	181	272	
1.2,4 - Trimethylbenzene	95636	110	810		1	< 50	NA NA		4,000	1,877	2,160	
1,2,5 - Trimethylbenzene	108676	< 50	160	< 50		< 50	AN		510 160	22 0	397 111	
s-Xviene	95476	< 50	1,200	210		< 50	NA NA		1,200	491	607	
m,p-Xylene	108383/108423	< 50	1,500		500	140	NA NA		1,500	583	905	
Mediylane chloride		< 50	< 50				NA		930	382	518	
Naphthalens	91203	120	< 50	< 50	J 67	< 50	NA	6?	120	30	86	
Nephthelens	91203	120	< 50	< 50	J et	< 50	NA	61		30	1	
Naphthatena	,	- •		< 50	J er{	< 50	NA	6?		,	1	•
Naphthatona	Samholatila Orga	inics — Me thod 6	2708 µg/kg						120	,	86 90% Confidence Interval	
	Semivolatile Orga CAS No.	inics — Met hod 8 R2—CR—01	2709 µg/kg R5-DR-01	R78-CR-01	F11-CR-01	914-CR-01	R15~CR-01	Average Conc	120	Std Dev	86 90% Contidence Interval Upper Limit	Comments
Anthracens	Semivolatile Orga CAS No. 120127	nnics Method 8 R2-CR-01 < 185	2708 µg/kg R5-CR-01 < 880	R7E-CR-01	F11-CR-01	R14-CR-01 < 165	R15~CR-01 J 140	Average Conc 148	120 Maximum Conc 140	Std Dav NA	86 90% Conlidence Interval Upper Limit NA	
Antifracens 8s (2 – ethylhexyl) phthelals	Semivolatile Orge CAS No. 120127 117817	nnics Method 8 R2-CR-01 < 165 < 165	270B µg/kg R5-CR-01 < 660 J 940	R7E - CR 01 < 165 < 165	F11-CR-01 < 165 370	R14-CR-01 < 165 < 165	R15 CR01 √ 140 < 165	Average Cono 148 328	120 Maximum Conc 140 940	Sid Dev NA 311	86 90% Confidence Interval Upper Limit NA 510	Comments
Antiracerse Bis (2 – ethylhexyl) phihelale Butyl berzyl phihelale	Semivolatile Orge CAS No. 120127 117817 65697	nics Method 8 R2-CR-01 < 165 < 165 < 185	2708 µg/kg R5-CR-01 < 800 J 840 J 310	R78 - CR - 01 < 165 < 165 < 165	F11-CR-01 < 165	R14-CR-01 < 165 < 165 < 165	R15~ CR~01 J 140 < 185 < 185	Average Conc 148 328 189	120 Maximum Conc (40 940 310	Sid Dev NA 311 59	90% Confidence Interval Upper Limit NA 516 225	Comments 1
Anthracens Bis (2 — ethylhexyl) phthelate Butyl benzyl phthelate D:n-butyl phthelate	Semivolatile Crgs CAS No. 120127 117817 85697 87742	nics Method 8 R2 - CR - Of < 165 < 165 < 165 < 165	2708 µgkg R5-CR-01 V 560 J 940 J 310 < 660	R7E-CR-01 < 165 < 165 < 165 < 165	F11-CR-01 < 165 370 < 165 J 230	R14-CR-01 < 165 < 165 < 165 < 165	R15~CR~01 J 140 < 165 < 165 J 67	Average Conc 148 328 189 154	120 Maximum Conc 140 940 310 230	Sid Dev NA 311 59 56	90% Confidence Interval Upper Limit NA 516 225 198	Comments
Antitracene Bis (2 – ethylhexyl) phthelate Butyl benzyl phthelate D:n-butyl phthelate Benz(a)antihracene	Semivolatika Cirge CAS No. 120127 117817 85017 87742 56553	nics - Method 8 R2-CR-01 < 165 < 165 < 165 < 165 4 165	2708 µgkg R5-CR-01 < 860 J 940 J 310 < 860 < 860	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165	F11-CR-01 < 165 370 < 165 J 230 < 165	914-CR-01 < 165 < 165 < 165 < 165 < 165	R15~CR-0: J 140 < 165 < 165 J 67 < 185	Awerage Conc 148 328 189 154 978	120 Maximum Conc 140 940 310 230 4,500	Std Dev NA 311 59 58 1,741	90% Confidence Interval Upper Limit NA 516 225 196 2,019	Comments 1
Anthracens Bis (2—ethylhexyl) phthelale Butyl benzyl phthelale D:-n-butyl phthelale Benz(a)anthracene Benzotkuoranthane (total)	Semivolutile Crge CAS No. 120127 117817 85087 87742 56553 NA	nics - Method 8 R2-CR-01 < 165 < 165 < 165 < 165 < 165 6,300	2708 µgkg R5-CR-01 < 660 J 940 J 310 < 660 < 660	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165	F11-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165	R15~ CR~01 J 140 < 165 < 165 J 67 < 165 < 165	Average Conc 140 324 189 154 970 1,601	Maximum Conc 140 940 310 230 4,500 8,300	SId Dev NA 311 59 59 1,741 3,287	86 90% Confidence Interval Upper Elmit NA 516 225 186 2,019 3,584	Comments 1
Anthracens Bis (2 — ethylhexyl) phthelale Butyl berzyl phthelale D:n — butyl phthelale Benz(a) anthracen Benzolkuranthene (total) Benzo(g, h, i) penjane	Semivolatika Cirge CAS No. 120127 117817 85017 87742 56553	nics - Method 8 R2-CR-01 < 165 < 165 < 165 < 165 4 165	2708 µgkg R5-CR-01 < 660 J 940 J 310 < 660 < 660	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R11-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15~CR-0: J 140 < 165 < 165 J 67 < 185	Average Conc 148 328 189 154 970 1,601	Maximum Conc (40) 940) 310 230 4,500 6,500	Std Dev NAA 311 59 58 1,741 3,267 2,554	86 90% Confidence Interval Upper Elmit NA 516 225 196 2.019 3,584 2,642	Comments 1
Anthracens Bis (2—ethylhexyl) phthelate Butyl berzyl phthelate D:-n-butyl phthelate Benz(a)enthracens Benzol(ucranitans (lotal) Benzo(g, h,l) penjene Benzo(a)pyrene	Semivolatile Crgs CAS No. 120127 117817 85607 87742 56553 NA 191242	nnics Method 6 R2 CR 01 < 165 < 165 < 165 < 165 4.500 6,300	270B µgkg R5-CR-01 < 500 J 940 J 310 < 600 < 680 < 680	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Fit1-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 J 67 < 165 < 165 < 165	Average Cone 148 328 189 156 978 1,603 1,303	Maximum Conc 140 940 310 230 4,500 8,300	SId Dev NA 311 59 59 1,741 3,287	86 90% Confidence Interval Upper Elmit NA 516 225 186 2,019 3,584	Comments 1
Anthracens Bis (2 — ethylhexyl) phthelale Butyl berzyl phthelale D:n — butyl phthelale Benz(a) anthracen Benzolkuranthene (total) Benzo(g, h, i) penjane	Semivolatila Crge CAS No. 120127 117817 85017 87742 56553 NA 191242 50328	nics Method 6 R2-CR-01 < 165 < 165 < 165 < 165 4,500 8,500 2,900	2708 µgkg R5-CR-01 < 560 J 940 J 310 < 660 < 660 < 660 < 660	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Fit1-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 J 67 < 165 < 165 < 165 < 165 < 165	Awerage Cone 140 328 189 154 970 1,801 1,300 701 184	Maximum Conc (40 440 310 230 4,500 8,300 8,500 2,900	Std Dev NA 311 59 56 1,741 3,287 2,554 1,004	86) 90% Confidence Interval Upper Limit 516 225 196 2.019 3.584 2.642 1,363	Comments 1
Antitracens Bis (2 - ethylhexyl) phthelate Butyl bengyl phthelate D:n - butyl phthelate Benz(a) enthracens Benz(a) enthracens Benzo(g, h, l) penjesne Benzo(g, h, l) penjesne Dibenz(a, h) enthracens	Semivolatile Crge CAS No. 120127 117817 85697 87742 56553 NA 191242 50328 53703	nics Method 6 R2 CR Of 165 165 165 165 1,500 6,300 6,500 2,900 J 260	2708 µgkg R5-CR-01 J 940 J 310 < 880 < 880 < 680 < 680 < 680	R76 - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	F111-CR-01 < 165	914-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Awerage Cone 148 228 189 156 970 1,003 1,300 703 184 2,038	Maximum Conc (40) 940 310 230 4,500 6,500 0,500 2,900 280	Std Dev NA 311 59 56 1,741 3,287 2,554 1,094	86] 90% Confidence Interval Upper Limit NA 516 225 196 2,019 3,584 2,642 1,363 213	Comments 1
Anthracens Bis (2 — ethylinexyl) phthelate Butyl benzyl phthelate D:n — butyl phthelate Benz(e) enthracene Benzotkuoranthane (total) Benzo(g, h,i) penjesne Benzo(e) pyrene Dibenz(e, h)enthracene 2.4— Dimethylphenol	Semivolatila Crge CAS No. 120127 117817 65617 87742 56553 NA 191242 50328 53703 105670	R2-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 4,500 6,500 2,900 J 260 < 165	2708 µgkg R5-CR-01 < 660 J 940; J 310 < 660 < 660 < 660 < 660 < 660	R76 - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R11-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R14-CR-D1 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Average Cone 148 328 159 154 070 1,600 1,300 703 184 2,604 867	Maximum Conc 140 940 310 230 4,500 6,300 6,500 2,900 2,900 15,800	Std Dav NA 311 59 58 1,741 3,287 2,554 1,094 42 6,050	86) 90% Confidence Interval Upper Eimit NA 516 225 196 2,019 3,584 2,842 1,363 213 8,287	Comments 1
Anthracens Bis (2 – ethylhexyl) phthelale Butyl benzyl phthelale D:n – butyl phthelale Benz(a) anthracene Benzo(bloronnhame (total) Benzo(g, h, i) penjisne Benzo(a) pyrene Dibenz(a, h) anthracene 2,4 – Dimethylphanol Chysene	Semivolatile Crgs CAS No. 120127 117817 85617 87742 56553 NA 191242 50328 53703 105670	nnics Method 6 R2 CR O1 < 165 < 165 < 165 < 165 4.500 6,300 6,500 2,900 J 260 < 165 4,000	2708 µg/kg R5-CR-01 < 500 J 940 J 310 < 500 < 600 < 660 < 660 < 660 < 660	R7E - CR - O1 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	F11-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R14-CR-D1 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Awerage Conc 148 328 189 156 970 1,801 1,300 703 184 2,034 887 1,053	Maximum Conc (40) 440 310 230 4,500 6,300 2,900 260 15,800 4,900	Std Dev NAA 311 59 58 1,741 3,287 2,554 1,094 42 6,056 1,538	86) 90% Confidence Interval Upper Limit 516 225 198 2,019 3,584 2,842 1,363 213 8,267 1,813	Comments 1
Antifracens Bis (2 - ethythexyl) phthelate Butyl benzyl phthelate D:-n - butyl phthelate Benz(e) antifracens Benzo(ucrantinans (total) Benzo(a, h) penjesne Benzo(a) pyrene Dibenz(a, h) enthiacens 2.4 - Dimethyl phenol Chysens Fluorantinans	Semivolatile Crge CAS No. 120127 117817 85607 87742 56553 NA 191242 50328 53703 105670 218019 206440	nics Method 6 R2 - CR - Of < 165 < 165 < 165 < 165 4.500 6,300 6,500 2,900 J 260 < 165 4,000 5,000	2708 µgkg R5-CR-01 J 940 J 310 < 660 < 660 < 660 < 660 15,000 < 660	R7E-CR-01 < 165 < 165	F11-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	914-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Awerage Conte 148 328 189 159 1,002 1,002 1,300 703 184 2,63a 887 1,053	Maximum Conc (40) 940 310 230 4,500 6,900 2,900 2,900 4,500 4,500 5,000	Std Dav NAI 311 59 56 1,741 3,287 2,554 1,094 42 6,056 1,538 1,944	86] 90% Confidence Interval Upper Limit NA 516 225 196 2,019 3,584 2,642 1,383 6,287 1,813 1,813 2,224	Comments 1 1
Antifracers Bis (2 - ethythaxyl) phthelate Butyl benzyl phthelate D:-n-butyl phthelate Benz(e)antifracers Benzo(uchniters) Benzo(uchniters) Benzo(a) pyrene Betzo(a) pyrene Dibenz(a,h) enthacers 2.4-Dimethylphenol Chysses Fluorente Indeno(1,2,3-c4) pyrene Isophocons	Semivolatile Crge CAS No. 120127 117817 85607 87742 56533 NA 191242 53703 105570 214010 20640 64737 19395	nics Method 6 R2 - CR - Of < 165 < 165 < 165 < 165 4.500 6,500 2,900 J 260 < 165 4,000 5,000 < 165 4,000 < 165	2708 µgkg R5-CR-01 J 940 J 310 < 660 < 660 < 660 15,000 < 660 < 660 < 660 < 660 < 660 < 660 < 660	R7E-CR-01 < 165 < 165	F111-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR01 J 140 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Awerage Conc 148 328 189 156 970 1,801 1,303 703 184 2,038 887 1,053 78 987 262	Maximum Conc (40) 940 310 230 4,500 6,500 2,900 260 15,000 4,000 5,000 78 4,500 650	Std Dev NAI 311 59 56 1,741 3,267 2,554 1,064 42 6,056 1,536 1,944 NAI 1,761 217	86] 90% Confidence Interval Upper Limit NA 516 225 198 2,019 3,584 2,842 1,303 213 8,287 1,813 2,224 NA 2,080 411	Comments 1 1
Antitracene Bis (2 - ethythexyl) phthelate Butyl benzyl phthelate D:n - butyl phthelate Benz(a) enthracene Benzo(a) pyrene Benzo(a) pyrene Dibenz(a, h) enthracene 2,4 - Dimethylphenol Chysene Fluorene Indeno(1,2,3 - c4) pyrene Isophorone 1 - Methylnaphthelene	Semivolatile Crge CAS No. 120127 117817 85697 87742 56553 NA 191242 50328 53703 105670 214010 20440 66737 193395 78591	nnics Method 6 R2 CR Of < 165 < 165 < 165 < 165 4.500 6,300 8,500 2,900 J 260 < 165 4,000 < 165 4,000 < 165 4,000 < 165 4,000	2708 µgkg R5-CR-01 S 660 J 940 S 660	R7E - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 330	F11-CR-01 < 165 370 < 165 J 220 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 330	\$14 - CR - D1 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 365 < 36	R15 CR 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	Awerage Cone 149 328 189 159 170 1,002 1,300 703 164 2,63a 887 1,053 78 987 262	Maximum Conc [40] 940 310 230 4,500 6,500 2,900 260 15,800 4,900 5,900 78 4,600 650 2,400	Std Dev NA 311 59 59 59 1,741 3,287 2,554 1,094 42 6,056 1,539 1,944 NA 1,761 217 926	86] 90% Confidence Interval Upper Limit NA 516 225 1,019 3,584 2,042 1,303 2,13 6,267 1,813 2,224 NA 2,060 411 1,656	Comments 1 1
Anthracens Bis (2 - ethythexyl) phthelate Butyl benzyl phthelate Di-n-butyl phthelate Benz(e) enthracene Benzoltuoranthane (total) Benzo(g, h, il) pentene Benzo(e) pyrene Dibenz(e, h) enthracene 2,4-Dimethylphenol Chysene Fluorenthene Fluorente Indeno(1,2,3-c4) pyrene leophotona 1 - Methylnaphthelene 2-Methylnaphthelene 2-Methylnaphthelene	Semivolatila Crge CAS No. 120127 117817 65617 87742 56653 NA 191242 50326 53203 105670 218010 208440 66737 193395 78591 90120	rinics Method 6 R2 CR Of < 165 < 165 < 165 < 165 4,500 8,500 2,900 J 260 < 165 4,000 < 165 4,000 < 165 4,000 < 165 2,000 < 165 2,000	2708 µgkg R5-CR-01 < 860 J 940 J 310 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 J 1,200 3,700	R76 - CR - 01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	F111-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR 01 165	Awerage Cone 140 328 189 154 970 1,003 1,300 703 184 2,03a 887 1,053 78 987 2,02 1,064 3,020	Maximum Conc (40) 940) 310 230 4,500 8,300 2,900 260 15,900 4,000 5,900 78 4,500 650 2,400	Std Dav NA 311 59 58 1,741 3,287 2,554 1,094 42 6,056 1,539 1,944 NA 1,781 217 926 4,220	86' Confidence Interval Upper Limit NA 516 225 196 2,019 3,584 2,642 1,363 213 6,267 1,813 2,224 NA 2,060 411 1,650 5,563	Comments 1 1
Antitracers Bis (2 - ethylibaxyl) phthelate Butyl berzyl phthelate Di-n - butyl phthelate Benz(a) snithracene Benz(a) snithracene Benzo(kuorantharse (total) Benzo(g, h,i) penjene Benzo(a) pyrene Dibenz(a, h) enthacene 2,4 - Dimethylphenol Chysene Fluorantharse Fluorantharse Indeno(1,2,3 - c4) pyrene Isophotona 1 - Methylnaphthelene 2 - Methylnaphthelene 2 - Methylphenol	Semivolatile Crge CAS No. 120127 117817 85607 87742 56533 NA 191242 53328 53703 105670 218010 20840 66737 193395 78591 90120 91576	Fig. 2.000 (165) Inics Method 6 R2 - CR - Of 1 185 (165) 185 (165) 4.500 8.500 2.000 J 260 4.000 5.000 165 4.000 5.000 165 2.000 165 2.000 165	2708 µgkg R5-CR-01 J 940 J 940 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 660 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650 < 650	R76-CR-01 < 165 < 165	R111-CR-01 < 165	R14-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15~CR~01 J 140 < 165 < 165 J 67 < 165 < 165	Awerage Cono 148 328 159 156 970 1,601 1,303 703 2,638 887 1,053 78 987 262 1,098 3,020 4,844	Maximum Conc 140 440 310 230 4,500 8,300 2,900 260 15,000 78 4,500 650 2,400 650 2,400 11,000 25,000	Std Dav NA 311 59 56 1,741 3,287 2,554 1,094 42 6,056 1,536 1,944 NA 1,761 217 926 4,220 9,652	86's Confidence Interval Upper Limit NA 516' 225' 198' 2.019' 3.584 2.642 1,363 213 8.287 1,813 2.224 NA 2,060 411 1,656 5,563 10,841	Comments 1 1
Antitracens Bis (2 - ethythexyl) phthelate Butyl bengyl phthelate D:n - butyl phthelate Benz(a) enthracens Benzo(a) pyrene Benzo(c), h, l) penjesne Benzo(c), h, l) penjesne Benzo(c), h, l) penjesne Benzo(c), h, l) penjesne Dibenz(a, h) enthracens 2,4-Dimethyl phenol Chysens Fluorente Indeno(1,2,3-c4) pyrene Isophocons 1 - Methyl naphthelene 2 - Methyl phenol 3,4 - Methyl phenol 3,4 - Methyl phenol	Semivolatile Crge CAS No. 120127 117817 85607 87742 56553 NA 191242 50328 53703 105679 218019 20440 60737 190305 78591 90120 91576 95467	nics Method 6 R2 CR Of R2 CR Of R2 CR Of R2 CR Of R300 R500 R500 R500 R500 R500 R500 R500	2708 µgkg R5-CR-01 J 940 J 310 < 660 < 660 2 4,000	R7E-CR-01 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 305 < 165 < 305 < 165 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305 < 305	F111-CR-01 < 165 370 < 165 J 230 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R14 - CR - o1 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	R15 CR - 01 - 165 - 1	Awerage Cone 140 328 189 154 970 1,601 1,300 703 184 2,038 887 1,053 78 987 202 1,098 3,020 4,844 4,888	120 Maximum Conc (40) 940 310 230 4,500 8,300 2,900 2,900 2,900 4,900 5,900 7,8 4,500 650 2,400 11,000 25,900 24,000	Std Dev NA 311 59 56 1,741 3,287 2,554 1,094 42 6,056 1,536 1,944 NA 1,761 217 926 4,220 9,952	90% Confidence Interval Upper Limit NA 516 225; 198 2.019 3,584 2,642 1,383 213 6,287 1,813 2,224 NA 2,060 411 1,650 5,563 10,841 10,624	Comments 1 1
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REFORMING CATALYST

		_											00% Conlidence	,
	TCLP Semivolati												interval	
	CAS No.		29.−01°	R5-CR-01	R78-CR-0		F11-CA-01	R14-CR-01	R15-CR-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
Bis (2-estythexy) phthe late	117817		60			O JB	61 <			52	51	4	55	
Di-n-butyl phthalets	84742	<	50			-, -	48 <	: 5 0		32	48	23	62	1, 2
2,4-Dimethylphanol	105679		50	460			50 <	50	< 50	115	450	167	219	·
1 – Methylnaphthalana	90120	J	34	J 18	< 100	0 <	100 <	180	< 100	25	34	13	53	1, 2
2 - Meshyinaphthalana	91576	J	43	< 50	< 50	0 <	50 <	50	< 50	43	43	NA	NA	1
2-Methylphenol	95487	<	50	620	< 56	0 <	50 <	50	< 50	145	520	233	285	•
3/4 - Methylphenol (totel)	NA	<	50	490	< 50	0 <	50 <	50	< 50	123	€90	160	232	
Nephthalens	01233	J	50	J 27	< 50	0 <	50 <	60	< 50	43	59	11	54	
Phenanthrono	85018	J	35	< 50	< 56	3 <	50 <	50	c 50	33	35	NA	NA	1
Planol	108952	<	60	B 380	< 50	> 10	50 <			105	380	135	186	•
	Total Melais — M	ethoda 60	10. 708	0. 7421. 7470. 74	71. and 7841 r	m rs/lke	1			•			90% Contidence interval	•
		R2-0		R5-CR-01	R78-CR-0		-	R14-CR-01	B16_78_01	Averege Cons	Maximum Canc	Std Day	Usper Limit	C
Aluminum	7429905		1000.0	180.000.0	480,000.0		290,000.0	150,000.0	190.000.0	250,000	460,000	113,666	318,492	Comments
Astimory	7440350	< -~	12.0	17.0			5.0 <		c 6.0		17.0			
Americ	7440382	2	10.0	45.0			20.0 <		11.0:	6.3 19.3	45.0	4.7	11.6	
Chromium	7440473	•	44.0	550.0	25.0		25.0	55.0	60.0			13.4	27.4	
Cobelt	7440484	<	10.0	2,900.0		٠,				126.5	550,0	208.0	251.8	
Copper	7440508	2	5.0	8,100.0		- :	5.0 <	*		488.3	2,900.0	1,161.5	1,200.3	
	1	<		-,	26.0	- 1	5.5 <		110.0	1,374.8	8,100.0	3,294.0	3,380.3	
lton .	7439826		460.0	51,000.0	2,100.0		120.0	500.0	5,400.0	9,930.0	51,000.0	20,215.9	22,111.6	
Lead	7430921	<	3.0		< 0.6		1.2	1.0		27.7	160.0	64,8	86.8	
Menganesa	7439935	≺	3.0	180.0	43.0		1.5 <		33.0	43.7	160.0	69.2	85.3	
Molybdenum	7439917	<	13.0	10,000.0	18.0	- 1	15.0 <		19.0	1,678.6	10,000.0	4,078.6	4,135.1	
Nickel	7440020	<	8.0	220.0	12.0		B.1 <		190.0	73.7	220.0	102.2	135.3	
Selentum	7782422	<	5.0	14.0			0.5	_,_		4.2	14.0	5.1	7.2	
Section	7440235		,000.0	10,000.0			500.0 <		c 500.0	2,166.7	10,000.0	3,842,7	4,482.2	
Venedium	7440622	<	10.0	70.0) <	5.0 <		c 5.0	21.0	76.0	28.0	37.9	
Zinc	7440688	<	4.D	2,900.0	< 2.0) <	2.0 <	2.0	20.0	485.3	2,900.0	1,181.5	1,200.3	
	TCLP Metals - M	ethods 13	111, 6 01	0, 7060,7421,74	170, 7471, e nd	784 1	ma/L					!	0% Confidence	ı
	CAS No.	R2-C		R6-CR-01	R7B-CR-01		•	314-CR-01	R15-C8-01	Average Cons	Maximum Conc	Std Dav	Uzper Limit	Comments
Auminum	7429905		28.00	6,30	360.00		340.00	94,00	23.00	141.72	380.00	164.24	240.68	CONTINUES
Chromlum	7440473	•	0.05	< 0.05	0.16		0.23 <		•	0.10	0.23	0.08	0.15	
Cobell	7440454	<	0.25	95.00		•	0.25 <	*****	c 0.25	16.04	95.00	38.66	39.35	
Copper	7440508		0.13	61.00			0.13	;	0.25	10.00	0100	24.84	25.27	
iron	7439896	<	0.50	< 0.60	8.00		2.50	1.20		2.35	490	3.30	4.34	
Land	7439921		0.02	< 0.02	1.10	1	1.70 <			0.48	1.70			
Manganesa	7439965	~	0.02	1.90	1.60	- 1	0.50	0.02	0.02	0.40	1.70	0.74 0.75	0.92	
Nickel	7440020		0.20	0.72	0.65		0.20 <		3.60:	19.0	1.50	1	1.26	
Seterium	7782492	<		< 0.03		1	0.20 <					1.30	1.73	
Znc		•				1		0.00		0.04	0.06	0.01	0.04	
Law	7440666		0.52	99.00	< 0.10	'1	0.30	0.50	0.25	16.78	99.00	40.28	41.05	

REFORMING CATALYST

	ı														
														90% Confidence	,
	Dioxine/Furans -	- Method 8290 i	ισ/kg											Interval	
	CAS No.	R2-CR-01	ı, F	96 CR01	R78-CR-01	, R	111-CR-01	R14-0			Average Conc	Maximum Conc	5ld Dev	Upper Limit	Comments
2,3,7,8-TCOF	51207319) <	0.29	< 0.21	ļ <	0.18	<	0.55	< 0.16	2.23	12.00	4.70	5.11	
Total TCOF	55722275	190.0) <	0.29	< 0.21	<	D.18		6.00	< 0.16	32.95	190.00	76.98	79.34	
1,2,3,7,8~PeCDF	57117416) <	0.70	0.47	١ <	0.35	<	0.95	< 0.32	BE.0	0.47	0.08	0.47	1
2,5,4,7,8-PeCOF	57117314	6.6) <	0.29	< 0.25	<	0.21	<	8.48	< 0.26	1.35	6.60	2.57	2.90	
Total PeODF	30402154	150.0		0.91	0.47	 <	g. 3 5		0.95	< 0.32	25.50	150.00	50.9D	62.25	
Tolai PeCDD	36088229			0.26	< 0.38	<	0.28	<	0.75	< 0.20	4.81	27.00	10.87	11.38	
1,2,3,4,7,8-HxCDF	70848269	24.0		0.28		<	0.14		0.65	< 0.25	4.26	24.00	9.67	10.09	
1,2,3,6,7,6—HxCDF	67117449			0.65	< 0.23	<	0.15		0.50	0.38	2.49	13.00	5.15	5.59	
2,3,4,6,7,8~HxCDF	60851345			0.31	< 0.39	1	Ø.31		0.75	0.41	0.35	0.41	0.05	0.40	1
1,2,3,7,8,9-HxCDF	72918219) <	0.70	< 0.35	١ <	Ø.17		1.00		1.87	8.70	3.36	3.90	
Total HxCOF	55884941	81.00		0.70	1.20	1	0.31		1.00	1.10	14.22	00.15	32.72	33.93	
Total HxCDD	34455468	20.0) <	0.55	< 0.75	<	0.70	<	1.60	< 0.32	3.96	20.00	7.86	8.72	
1,2,3,4,6,7,6-HpCDF	67562394	29.0	וְנ	2.20	1.70	 <	0.12	<	t.00	0.53	5.76	29 00	11.41	12.63	
1,2,3,4,7,8,9-HpCOF	55873897	18.0) <	0.49	< 1.30	<	D.24	<	1.00	< 0.21	3.54	18.00	7.10	7.82	
Total HpCDF	38998763	71.0		5.10	5.90) <	0.24	<	1.00	0.53	19.96	7100	26.05	30.88	
1,2,3,4,6,7,8-HpCOD	35822489	25.0		0.90	6.40	 <	0.22		2.20	0.44	7.36	28 00	10.51	13.59	
Total HpCDD	. 37871084	62.0		13.00	11.00	¹ <	0.22		2.20	0.92	13.22	5200	19.75	25.13	
OCOF	39001020			4.70	9.30	<	0.41	<	3.35	0.96	8.62	33 00	12.38	16.07	
OCDD	3266679	28.0		51.00	76.00	1	1.30		46.00	4.30	34.77	78.00	29,10	52.30	
2,5,7,6-TODD Equivalence	1746016	9.9		0.15	0.19	1	0.03		0.07	0.00	1.74	9.90	4.00	4.15	

Comments:

- Detection limits greater than the highest detacted concentration are excluded from the calculations.

 Upper limit exceeds the maximum concentration.

- Analyse see detected in the essociated method blank.
 Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the leboratory detection limit, but greater than zero.
- NO Noi Detected.
 NA Noi Applicable.

3.4.2.4 Source Reduction

Like other catalysts, little can be done to reduce the volume of this residual. The catalyst will always, eventually, become inactive and require replacement. Efforts to decrease the frequency of generation or to decrease the toxicity of the generated residual appear to be the greatest opportunities for pollution prevention.

One refinery reported in its RCRA §3007 questionnaire that its reforming catalysts are now nonhazardous due to a new sweep procedure, reducing the facility's requirement to ship them as hazardous waste. Benzene and other light hydrocarbons are common contaminants in reforming catalyst. Another facility decreases the frequency of turnarounds by optimizing the feed. The quantity of material sent offsite can be reduced by separating the support material for onsite reuse. Many facilities perform this separation step already, but other techniques such as screening or air cyclones could be used to increase efficiency.

3.5 SULFURIC ACID ALKYLATION

3.5.1 Process Description

In the sulfuric acid alkylation process, olefin and isobutane gases are contacted over concentrated sulfuric acid (H_2SO_4) catalyst to synthesize alkylates for octane-boosting. The reaction products are separated by distillation and scrubbed with caustic. Alkylate product has a Research Octane Number in the range of 92 to 99. Figure 3.5.1 provides a generic process flow diagram for H_2SO_4 alkylation.

Caustic Isobutane Propane Caustic Acid Olefins · Reactors Wash Separators **Fractionation** Isobutane Spent Caustic Make-up Recycled Acid Acid n-Butane Catalyst Spent Acid Spilled Acid Run-off Catalyst Alkylate Lime Neutralization Pit Water to _ WWTP Neutralization Sludge

Figure 3.5.1. H₂SO₄ Alkylation Process Flow Diagram

The olefin stream is mixed with the isobutane and H₂SO₄ in the reactor. To prevent polymerization and to obtain a higher quality yield, temperatures for the H₂SO₄ catalyzed reaction are kept between 40 and 50°F (McKetta, 1992). Since the reactions are carried out below atmospheric temperatures during most of the year, refrigeration is required. Pressures are maintained so all reaction streams are in their liquid form. The streams are mixed well during their long residence time in the reactor to allow optimum reaction to occur.

The hydrocarbon/acid mixture then moves to the acid separator, where it is allowed to settle and separate. The hydrocarbons are drawn off the top and sent to a caustic wash to neutralize any remaining trace acid. The acid is drawn from the bottom and recycled back to the reactor. A portion of the acid catalyst is continuously bled and replaced with fresh acid

to maintain the reactor's acid concentration around 90 percent. This spent H₂SO₄ is a residual of concern.

In the fractionator, the hydrocarbon streams are separated into the alkylate and saturated gases. The isobutane is recycled back into the reactor as feed.

In 1992, DOE reported a U.S. alkylate capacity of 1,083,154 BPSD from 103 refineries (49 facilities used H₂SO₄ alkylation)

Some facilities have neutralization tanks (in and above ground), referred to as pits, which neutralize spent caustic and any acid generated from spills prior to discharge to the WWTP, serving as surge tanks. Neutralizing agents (sodium, calcium, potassium hydroxides) are selected by the refineries. If necessary, the effluent to the pit is neutralized and, depending on the neutralizing agent, the precipitated salts form a sludge. This sludge is a residual of concern. Sludge may also be generated in process line junction boxes, in the spent H_2SO_4 holding tank, and during turnaround. However, due to the aqueous solubility of sodium, calcium, and potassium sulfates, sludge generation rates are relatively low and the majority of neutralization salts (e.g., sodium sulfate) are solubilized and discharged to the WWTP.

3.5.2 Spent Sulfuric Acid - Residual 10

3.5.2.1 <u>Description</u>

A slip stream of spent sulfuric acid is continuously drawn off the acid settler and replaced with fresh acid to maintain an acid strength of 90 to 92 percent. The spent acid, typically 100-300 tons per day, is either sent to an onsite acid plant for regeneration or, more commonly, sent offsite via tanker truck, railcar, or barge to a sulfuric acid supplier for reclamation.

Spent sulfuric acid used to produce virgin sulfuric acid, unless it is accumulated speculatively, is excluded from the definition of solid waste, as provided in Section 261.4(a)(7). The §3007 questionnaire results support the industry's claim that greater than 99 percent of the spent acid is reclaimed.

The spent acid exhibits the RCRA characteristic for corrosivity. Currently, 17 facilities reported managing their spent acid as corrosive, which represents 251,199 MT of the waste. The Agency expects that all of this residual would fail the corrosivity characteristic if tested, however, due to the

According to the Oil and Gas Journal, growth in H₂SO₄ regeneration is expected through 1995 due to increased demand for alkylate, environmental pressures, and reformulation of gasoline.

existing exemption, the characteristic does not apply and thus was not uniformly reported.

3.5.2.2 Generation and Management

The §3007 questionnaire responses indicated 1,760,071 MT of spent H₂SO₄ acid were generated in 1992. Residuals were assigned to be "spent sulfuric acid alkylation catalyst" if they were assigned a residual identification code of "spent liquid catalyst" and was generated from a process identified as a sulfuric acid alkylation unit. This corresponds to residual code 03-C in Section VII.2 of the questionnaire and process code 03-C in Section IV-1.C of the questionnaire. In this industry study, spent H₂SO₄ was the largest-volume waste being examined, twice the volume of the next largest-volume waste. Table 3.5.1 provides a description of the total quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

The RCRA §3007 questionnaire showed that spent H₂SO₄ is continuously drawn off the unit to either a holding tank, an onsite acid regeneration plant, or directly offsite to a reclaimer. At least 1,072,000 MT of sulfuric acid are managed in tanks.

Greater than 99 percent of the 1,760,071 MT of spent acid generated at 45 refineries is either used as replacement catalyst, regenerated onsite, or sent offsite for regeneration. Insignificant amounts of acid from spills are managed at the WWTP and discharged either to a POTW or to surface waters under a NPDES permit.

Table 3.5.1. Generation Statistics for Spent H ₂ SO ₄ Alkylation Catalyst								
Final Management	# of Streams	# with Unreported Volumes	Total Volume (MT)	Average Volume (MT)	90th % Volume (MT)			
Discharge to WWTP; discharge to surface waters; discharge to POTW	6	2	154.76	26	150			
Offsite incineration	1	0	0.09	0.09	0.09			
Reuse onsite as replacement catalyst	2	0	87,400	43,700	43,700			
Transfer of acid for reclamation	38	1	1,424,162	37,478	74,414			
Onsite acid regeneration/ onsite sulfuric acid plant	7	2	248,355	35,479	98,000			
Total spent H ₂ SO ₄	54	5	1,760,071	31,429	66,000			

No plausible management scenarios for final management were identified for the use in the risk assessment due to the fact that the information collected in the §3007 survey supported the assumption that greater than 99 percent of the spent acid is reclaimed and, therefore, is covered by the existing exclusion. A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.5.2.

Table 3.5.2. Selection of Risk Assessment Modeling Scenario: Spent H ₂ SO ₄ Alkylation Catalyst					
Waste	Basis for Consideration in Risk Assessment				
Discharge to WWTP; discharge to surface waters; discharge to POTW	Not modeled, very small volume and existing coverage of current listings				
Offsite incineration	Not modeled, de minimis volume				
Reuse onsite as replacement catalyst	Not modeled, exempt management practice				
Transfer of acid for reclamation	Not modeled, exempt management practice				
Onsite acid regeneration/onsite sulfuric acid plant	Not modeled, exempt management practice				

3.5.2.3 Characterization

Due to the pre-existing RCRA exclusion, residual characterization information was collected only in the §3007 survey and no record samples were collected for this residual of concern. Table 3.5.3 summarizes the physical properties of the tank sludge as reported in Section VII.A of the §3007 survey. One familiarization sample was collected and the characterization data for it is presented in Table 3.5.4.

Table 3.5.3. H ₂ SO ₄ Alkylation Catalyst Physical Properties							
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %		
pН	35	29	1.0	2.23	3		
Reactive CN, ppm	4	60	0	62.75	250		
Reactive S, ppm	3	61	0	33.3	100		
Flash Point, °C	10	54	60	103.9	183.6		
Oil and Grease, vol%	4	60	0	3	8		
Total Organic Carbon, vol%	8	56	0	3.3	5		
Viscosity, lb/ft-sec	9	55	0.01	1.1	10		
Specific Gravity	32	32	1.12	1.7	1.83		
BTU Content, BTU/lb	3	61	0	233	700		
Aqueous Liquid, %	43	21	100	84	100		
Organic Liquid, %	37	27	0	5.3	10		
Solid, %	34	30	0	3.1	2		

Table 3.5.4. H₂SO₄ Alkylation Catalyst Familiarization Characterization Sample

Volatile Organics - Method 8260A μg/L CAS No.	
Methylene chloride 75092 B 31,000 Methyl ethyl ketone 78933 35,000 Semivolatile Organics — Method 8270B μg/L CAS No. B—SA—01 None Detected NA NA Total Metals — Methods 6010, 7060, 7421, 7470, 7471, and 7841 p.	
Methylene chloride 75092 B 31,000 Methyl ethyl ketone 78933 35,000 Semivolatile Organics — Method 8270B μg/L CAS No. B—SA—01 None Detected NA NA Total Metals — Methods 6010, 7060, 7421, 7470, 7471, and 7841 p.	
Methyl ethyl ketone 78933 35,000 Semivolatile Organics — Method 8270B μg/L CAS No. B—SA—01 None Detected NA NA NA NA Total Metals — Methods 6010, 7060, 7421, 7470, 7471, and 7841 p.	
Semivolatile Organics — Method 8270B µg/L CAS No. B—SA—01 NA NA Total Metals — Methods 6010, 7060, 7421, 7470, 7471, and 7841 p	
CAS No. B-SA-01 None Detected NA NA Total Metals - Methods 6010, 7060, 7421, 7470, 7471, and 7841 /	
CAS No. B-SA-01 None Detected NA NA Total Metals - Methods 6010, 7060, 7421, 7470, 7471, and 7841 /	
None Detected NA NA Total Metals - Methods 6010, 7060, 7421, 7470, 7471, and 7841 /	
Total Metals - Methods 6010, 7060, 7421, 7470, 7471, and 7841	
	(1
CAR No. D. DA 04	ոց/ւ
CAS No. B-SA-01 Aluminum 7429905 4.1	
Arsenic 7440382 0.12	
Calcium 7440702 15.9	
Chromium 7440473 1.5	
Copper 7440508 0.52	
Iron 7439696 50.3	
Manganese 7439965 0.33	
Moylbdenum 7439987 0.60	
Nickel 7440020 0.82	
Sodium 7440235 37.5	
Zinc 7440666 0.27	
Miscellaneous Characterization	
B-SA-01	
Corrosivity (pH)	

Notes

B Analyte also detected in the associated method blank.
NA Not Applicable.

3.5.2.4 Source Reduction

Even though refiners recycle all of their spent H₂SO₄, they still are required to handle large quantities of acid. Transporting and handling these large volumes of spent acid poses significant potential risks due to transportation accidents and human error. Refiners and service companies

According to the Oil and Gas Journal, many refiners stated that, if a solid-acid process with economics comparable to sulfuric acid alkylation was available, they would consider it for new units.

are in the process of developing solid-acid catalysts to be used in the alkylation process.

Several solid-acid catalysts used for alkylation are being tested in pilot plants. The solid-catalyst reactor systems are different from the current liquid-acid systems, but for one solid-catalyst operation, the other process equipment is compatible. The three types of new solid catalyst include aluminum chloride, alumina/zirconium halide, and antimony pentafluoride (a slurry system).

3.5.3 Sludge from Sulfuric Acid Alkylation - Residual 11

3.5.2.1 Description

As discussed above, some facilities have neutralization pits, which neutralize streams headed to the WWTP, serving as surge tanks. Sludges occur from neutralizing salts (although most salts are soluble), settling polymer/tars, and dirt washed into process sewers. Sludge may also be generated in process line junction boxes, in the spent H₂SO₄ holding tank, and during turnarounds. Typical neutralizing agents include lime, sodium hydroxide, calcium chloride, and potassium hydroxide. Depending on the neutralizing agent (i.e., calcium hydroxide), precipitated salts form and settle to the bottom of the pit. These salts or sludges must be periodically cleaned out. Potassium and sodium sulfate salts are soluble in water, therefore, no sludges are generated.

Most refineries have switched from insoluble neutralizing agents (e.g., lime) to the soluble agents (e.g., sodium hydroxide, potassium hydroxide). The soluble sulfates do not create a sludge in the pits and are carried with the effluent to the WWTP. This practice has significantly reduced the amount of these sludges generated by refineries.

Two facilities reported managing their H₂SO₄ alkylation sludge as hazardous. These waste streams were managed either as F037 or as corrosive wastes.

3.5.2.2 Generation and Management

The questionnaire responses indicated 608 MT of H₂SO₄ alkylation sludge were generated in 1992. Residuals were assigned to be "sulfuric acid alkylation sludge" if they were assigned a residual identification code of "alkylation neutralization sludge" or "other process sludge" and was generated from a process identified as a sulfuric acid alkylation unit. These correspond to residual codes 02-B and 02-D, respectively, in Section VII.2 of the questionnaire and process code 09-A in Section 1V-1.C of the questionnaire. Spent H₂SO₄ catalyst was mischaracterized as sludge in the 1983 RCRA survey and subsequent documents used to identify the consent decree wastes. The 1983 corrected data indicated only 482 MT of sludge was generated, not 61,338 MT. Table 3.5.5 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

The questionnaire responses reported that 17 MT of sludge were disposed of in either Subtitle D or C landfills in 1992. Approximately 380 MT of sludge were managed in land treatment units.

Table 3.5.5. Generation Statistics for H ₂ SO ₄ Alkylation Sludge							
Final Management	# of Streams	# of Unreported Volume Streams	Total Volume (MT)	Average Volume (MT)	90th Percentile Volume (MT)		
Transfer of acid for reclamation	2	0	80	40	40		
Disposal offsite Subtitle D landfill	2	1	10	5	10		
Disposal offsite Subtitle C landfill	1	0	7	7	7		
Discharge to WWTP; discharge to surface water	3	3	130	43	120		
Offsite land treatment	1	0	100	100	100		
Onsite land treatment	2	0	280	140	278		
Offsite incineration	1	0	1	1	1		
Total H ₂ SO ₄ alkylation sludge	12	4	608	47	120		

¹ Process upset sludge 80-95% acid.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.6.1 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite land treatment (46% of sludge)
- Offsite land treatment (16.4% of sludge)
- Offsite Subtitle D landfilling (about 2% of sludge)

An onsite monofill scenario was rejected because of the intermittent generation frequency, which is not typical of waste that tends to be monofilled. Similarly, the Agency did not model interim storage of sludge prior to final management. This residual is infrequently generated, and space and cost constraints create incentives for the refineries to minimize on-site storage.

The sludges managed in wastewater treatment systems were not chosen for evaluation in the risk assessment because these sludges will settle out in the primary treatment steps and are already listed as hazardous.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.5.6.

Characterization data for the management units and their underlying aquifers were reported in the §3007 survey. Table 3.5.7 provides a summary of the data for the targeted management practices used in the risk assessment.

Table 3.5.6. Selection of Risk Assessment Modeling Scenario: H ₂ SO ₄ Alkylation Sludge					
Final Management	Basis for Consideration in Risk Assessment				
Transfer of acid for reclamation	Not modeled, exempt management practice				
Disposal offsite Subtitle D landfill	Modeled				
Disposal offsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control				
Discharge to WWTP; discharge to surface water	Not modeled. Minimal volume. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be captured by existing hazardous waste listings and further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.				
Offsite land treatment	Modeled				
Onsite land treatment	Modeled				
Offsite incineration	Not modeled, de minimis volume				

¹ Process upset sludge 80-95% acid.

Table	3.5.7. N	fanageme	nt Practices	Targeted f	or Risk A	ssessment	
		\mathbf{H}_{2}	O₄ Alkylatio	n Sludge			
Parameters	# of Fac.	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Offsite Subtitle D Landfill ¹	2	2	1	10		5	10
Offsite Land Treatment Unit	1	1	0	100	****	100	100
Onsite Land	1	2	0	280	<u> </u>	280	280
Treatment Unit ³				Characteristic	s		
	Surface	Area (acres)			15	20.2	170
	Depth o	f Incorporatio	on (in)		5	8	12
	Amount	Applied (199	2 MT) ²		74.3	5,129	6,100
	Methods	of Incorpor	ntion: Disking (3)				
	# of Lar	d Treatment	Units: 3				
			A	quifer Informa	tion		
	Depth to	Aquifer (ft)			15	15	15
	Distance	to Private V	Vell (1000 ft)		25	25	25
	. Populati	on Using Pri	vate Well		0 .	0	0
	Distance	to Public W	ell (ft)		***	**	
	Populati	on Using Put	olic Well		_		
	# of Aqı	uifers: 3					
	Source: Unrepor Upperm		Public 3	<u>Privat</u> 2 1	E		
	Classific	Current or p	ermost Aquifer: potential source of red a potential sou (1)				

¹ The mean and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream from one refinery may be disposed of in one management unit causing the 90th percentile number actually to be the sum of 2 or 3 waste volumes).

² Volumes represent the average volume of all wastes applied to the land treatment units accepting the alkylation sludge and not just the sludge alone.

not just the sludge alone.

The number of onsite land treatment units characterized in Table 3.5.7 is greater than indicated in Table 3.5.5 which focuses only on volumes generated in 1992. Table 3.5.7 incorporates data from all onsite land treatment units receiving sulfuric acid alkylation sludge in any year reported in the §3007 survey.

3.5.2.3 Characterization

Due to changes in management practices (i.e., changing from an insoluble neutralizing agent to a soluble one), samples of neutralization pit sludges were very difficult to obtain. Sludges generated in junction boxes and spent H_2SO_4 tanks are accessible only during unit turnaround every 2 to 5 years. These stipulations made sample procurability very difficult during the time of the field study. The number of refineries chosen for record sampling was expanded to increase the availability of this residual, however, the newly targeted samples were never actually available.

Two sources of residual characterization were developed during the industry study:

- Table 3.5.8 summarizes the physical properties of the sludge as reported in Section VII.A of the §3007 survey.
- One sample of H₂SO₄ alkylation sludge was collected and analyzed by EPA.
 Sample location is expressed in Table 3.5.9. Table 3.5.10 provides the characterization data for this sampling effort.

Table 3.5.8. H	₂SO₄ Alky	lation Sludge P	hysical Pr	operties	
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %
pН	17	15	1.0	5.5	9.8
Reactive CN, ppm	3	29	0	1667	250
Reactive S, ppm	4	28	0	50	100
Flash Point, °C	6	26	43.9	84.4	200
Oil and Grease, vol%	10	22	0	1.6	3.6
Total Organic Carbon, vol%	7	25	0.04	6.6	25
Specific Gravity	10	22	1.0	8.5	36
BTU Content, BTU/lb	2	30	100	800	1,500
Aqueous Liquid, %	11	21	0	12.6	25
Organic Liquid, %	11	- 21	0	8.4	5
Solid, %	11	21	20	79	100

Table 3.5.10 provides the characterization data for this sample. Only constituents detected in at least one sample are shown in this table. The sludge sample exhibited the toxicity characteristic for chromium and the corrosivity characteristic.

Table	3.5.9. H ₂ SO ₄ Alkylation S	ludge Record Sampling Locations
Sample number	Facility	Description: Type of Generating Unit, Catalyst
R8B-SS-01	Amoco, Texas City, TX	Neutralization sludge from H ₂ SO ₄ alkylation unit and H ₂ SO ₄ plant, dredged from pit

3.5.2.4 Source Reduction

As mentioned previously, most refineries have switched from insoluble neutralizing agents (e.g., lime) to the soluble agents (e.g., sodium hydroxide, potassium hydroxide). The soluble sulfates do not create a sludge in the pits and are carried with the effluent to the WWTP. This practice has significantly reduced the amount of these sludges generated by refineries.

Another practice that has reduced the amount of sludge generated is the reduction of the frequency and method of testing the acid strength. By reducing the frequency of testing acid concentration from once every 2 hours to twice a day, the amount of neutralizing agent needed and the amount of solids and acid tars accumulating on the pit bottom have been reduced, because the sample port purge volumes are reduced.

Table 3.5.10. H₂SO₄ Alkylation Sludge Characterization

			_
	Volatile Organics -		⊬g /kg
	CAS No.	R88-88-01	
Acetone	07041	7,000	
Ethylbenzene	100414 J	150	
Toluene	108883 J	160	
1,2,4 - Trimethy benzene	95836 J	280	
m,p - Xylenes	108383 / 106423 J	170	
Naphihalene	91203 J		
I respect to market to	7.222	/	
	TOTAL Voletile Own	nice – Wethoda	1311 and 6260A μg/L
	CAB No.	R88-SS-01	7071a/B accorpge
Acitone	67041	810	
Meltrylene chionde	75092 B		
Methyl ethyl ketone	78933	120	
menth enth terrore	,,,,,,	,,,,	
	Semivolatile Organ	dan Bladbard O	2700 8
	CAS No.	R&B 88 01	s too billing
And the second second	1 .		l
Bis (2 - ethylhexyl)phthalate	117817	£,000	
Di-n-butyi phtheiate	84742 J		
Benz(a)anihracene	56553 J		
Benzo(g,h./ipenjiene	191242 J		
Benzo(a)pyrene	50328 J		
Chrysene	218019 J		
Fluorene	86737 J		
Phenanthrene	85018 J		
Pyrene	129000	2,200	
1 - Mathylnaphthalene	90120 J	.,	
2 - Methylnaphthaiene	91576	2,200	
2-Mathylchrysere	3351324 J		
Naphthelene	91203 J	290	
	TCLP Semivolatile	Organics - Mai	thods 1311 and 6270B µg/L
	CAS No.	R8B-88-01	
1 – Methylnephthalene		PBB-88-01	
i – Methyinephitalene 2 – Methyinephitalene	CAS No.	R8B-85-01 24	
	CAS No. 90120 J	R8B-88-01 24 31	
2-Melhylnaphthalene	CAS No. 90120 J 91576 J	R8B-88-01 24 31	
2-Melhylnaphthalene	CAS No. 90120 J 91576 J 91203 J	R8B-8S-01 24 31 30	
2-Melhylnaphthalene	CAS No. 90120 J 91576 J 91203 J	R8B-8S-01 24 31 30	
2-Melhylnaphthalene	CAS No. 90120 J 91576 J 91203 J Total Metals — Met	A8B -8S -01 24 31 30 thads 6010, 706	
2-Melhyinghthelene Naphthelene	CAS No. 90120 J 91576 J 91203 J Total Metals Met CAS No.	A8B-8S-01 24 31 30 thods 6010, 706 R8B-8S-01	
2-Melhyinghthelene Naphthelene Aluminum	CAS No. 90120 J 91576 J 91203 J Total Metale — Me CAS No. 742905	R8B - 88 - 01 24 31 30 thods 6010, 706 R8B + 85 - 01 1, 100	
2-Melhytraphthelene Naphthelene Aluminum Artimony	CAS No. 90120 J 91576 J 91203 J Total Metals – Mer CAS No. 742905 7440360	R8B = 88 = 01 24 31 30 thods 0010, 700 R8B = 85 = 01 1, 100 5.8	
2-Melhytraphthelene Nephthelene Aluminum Antimony Asseric	CAS No. 90120 J 91576 J 91203 J Total Metals — Mer CAS No. 742905 7440380 7440382	R8B = 88 01 24 31 30 thods 6010, 706 R8B 85 01 1, 100 5.8 2.4	
2-Melhyinghthelene Naphthelene Aluminum Artimony Ansenic Berium	CAS No. 90120 J 91576 J 91203 J Total Metals — Mer CAS No. 7429005 7440360 7440382 7440393	ReB = \$8 01 24 31 30 thods 6010, 706 ReB +85 01 1, 100 5.8 2.4 3.2	
2 - Melhyinghithelene Naphthelene Aluminum Antimony Ansenic Barium Cadmium Calcium	CAS No. 90120 J 91576 J 91203 J 91203 J Total Metals — Mer CAS No. 7429005 7440380 7440382 7440439	ReB = 88 01 24 31 30 thods 6010, 706 ReB 88 01 1, 100 5.8 3.2 0.09	
2 - Melhyinghithelene Naphthelene Aluminum Artimony Ansenic Berum Catrium Calcium Chromium	CAS No. 90120 J 91576 J 91203 J 91203 J 91203 J Total Metals — Mer CAS No. 7429005 7440382 7440382 7440439 7440702	R8B - 88 - 01 24 31 30 thods 6010, 706 R8B + 85 - 01 1, 100 5.8 2.4 3.2 0.09	
2 - Melhyinaphthelene Naphthelene Aluminum Artimony Arsenic Berium Cedmium Celonium Chomium Chomium Cchell	CAS No. 90120 J 91576 J 91203 J 91203 J 71203 J Total Metals ~ Met	ReB = 88 01 24 31 30 thode 6010, 706 ReB +8 5 - 01 1, 100 5.8 2.4 3.2 0.09 16,000	
2-Melhyinaphthelene Naphthelene Aluminum Arkmony Arsenic Barium Cadmium Calcium Chromium Cobat Copper	CAS No. 90120 J 91576 J 91203 J 91203 J Total Metals Metals Metals Metals Metals Metals Metals Metals Metals 7440392 7440492 7440473; 7440484	ReB = \$\$ = 01 24 31 30 thods 6010, 706 ReB = \$\$ = 01 1, 100 5.8 2.4 3.2 0.09 16,000 190 3.3	
2-Methylagothelene Naphthelene Aluminum Anthrony Arsenic Berium Cedmium Celoium Chiomium CobeR Copper	CAS No. 90120 J 91576 J 91576 J 91203 J 71203 J Total Metals — Mer CAS No. 7429905 7440382 7440393 7440439 7440404 7440506	R8B-88-01 24 31 30 30 30 40 40 40 40 40 40 40 40 40 40 40 40 40	
2-Methylagothelene Naphthelene Aluminum Antimony Ansenic Barium Cadmium Calcium Chromium Colost Copper Iron Lead	CAS No. 90120 J 91576 J 91203 J 91576 J 91203 J 71203 J 7440360 7440382 7440439 7440404 7440606 7439890	R8B - 88 - 01 24 31 30 thods 6010, 706 R8B + 85 - 01 1, 100 5.8 2,4 3,2 0.09 16,000 190 3,3 37.0 6,600,00	
2-Methylraphthelene Naphthelene Aluminum Artimony Arsenic Barium Cadmium Calcium Chromium Cobeit Copper Iron Leed Magneeium	CAS No. 90120 J 91576 J 91203 J 91203 J 91203 J 71203 F 91203 J 91203 F 91203	ReB = 88 = 01 24 31 30 thode 6010, 706 ReB ⇒ 85 = 01 1, 100 5.8 2.4 3.2 0.09 16,000 190 3.3 3.7.0 6,800.00	
2-Methylagothelene Naphthelene Aluminum Arkmony Arsenic Barium Cadmium Calcium Chromium Cobait Copper Iron Lead Magnesium Manganese	CAS No. 90120 J 91576 J 91203 J 91203 J 91203 J 701203 J 701203 J 701203 J 701205 T	ReB = \$\$ 01 24 31 31 30 4 4 5.8 7.00 5.8 2.4 3.2 0.09 15,000 190 3.3 37.0 6,600.00	
2-Melhyinaphthelene Naphthelene Aluminum Anthrony Arsenic Barium Cadmium Calcium Chromium Criconium Criconium Cobar Copper Iron Lead Magneseum Manganese Mercury	CAS No. 90120 J 91576 J 91203 J 91576 J 91203 J 91203 J 740360 7440382 744039 7440404 7440506 743990 743995 743995 7439976	R8B = 88 = 01 24 31 30 thods 6010, 706 R8B = 88 = 01 1, 100 5.8 2.4 3.2 0.09 160,000 190 3.3 37.0 6,600,00 23.0 670 45.0	
2-Methylagothelene Naphthelene Aluminum Ankmony Arsenic Berium Cedmium Celcium Chromium Ccheit Copper Iron Leed Magneeium Manganee e Mercury Moybdenum	CAS No. 90120 J 91576 J 91203	R8B = 88 = 01 24 31 30 thods 6010, 706 R8B = 88 = 01 1, 100 5.8 2.4 3.2; 0.09 16,000 190 3.3 37.0 6,800,00 45.0 0.035	
2-Methylnaphthalene Naphthalene Aluminum Artimony Arsenic Barium Cadmium Calcium Chromium Cobait Copper Iron Lead Magneeium Mangenee e Mercury Moy bolenium Nickel	CAS No. 90120 J 91576 J 91203 J 91203 J 91203 J 91203 J 701203 J 7	R8B = \$\$ = 01 24 31 30 thode 6010, 706 R8B = \$\$ = 01 1, 100 5.8 2.4 3.2 0.09 16,000 190 3.3 37.0 6,800,00 20,0 45.0 0.035 1.7 280	
2-Melhyinaphthelene Naphthelene Aluminum Arkmony Arsenic Barium Cadmium Calcium Chromium Cobait Copper Iron Lead Magnesium Manganes s Mercury Moybdenum Nickel Potasskum	CAS No. 90120 J 91576 J 91576 J 91576 J 91203 J 71203 J 7420905 7440392 7440393 7440404 7440506 7430906 7430906 7430907 7440020 7440020 7440020 7440020 7440020 7440020 7440020 7440020	R8B = 88 = 01 24 31 30 30 30 88B = 88 = 01 1, 100 5.8 2.4 3.2 0.09 16,000 190 3.3 37.0 6,800.00 23.0 670 45.0 0.035 1.7 280 200	
2-Melhyinaphthelene Naphthelene Aluminum Antimony Arsenic Barium Cadmium Calcium Chromium Cobar Copper Iron Lead Magneeium Marganees Mercury Moybdenum Nickel Potassium Sodium	CAS No. 90120 J 91576 J 91576 J 91576 J 91203 J 91203 J 740360 7440382 744039 7440484 7440508 743995 743995 743995 743995 743995 7439978 7440020 7440000 7440000 7440000 7440000 7440000 7440000 7440000 7440000 7440000 7440000 7440000 7440000 74400	R8B = 88 = 01 24 31 30 thods 6010,706 R8B = 88 = 01 1,100 5.8 2.4 3.2 0.09 160,000 190 3.3 37.0 6,600,00 23.0 6,70 45.0 0.035 1,7 280 0.000	
2-Melhyinaphthelene Naphthelene Aluminum Arkmony Arsenic Barium Cadmium Calcium Chromium Cobait Copper Iron Lead Magnesium Manganes s Mercury Moybdenum Nickel Potasskum	CAS No. 90120 J 91576 J 91576 J 91576 J 91203 J 71203 J 7420905 7440392 7440393 7440404 7440506 7430906 7430906 7430907 7440020 7440020 7440020 7440020 7440020 7440020 7440020 7440020	R8B = 88 = 01 24 31 30 30 30 88B = 88 = 01 1, 100 5.8 2.4 3.2 0.09 16,000 190 3.3 37.0 6,800.00 23.0 670 45.0 0.035 1.7 280 200	

SLUDGE from BULFURIC ACID ALKYLATION

	TCLP Metals - Med	[CUP Metals - Methods 1311, 5010, 7000, 7421, 7470, 7471, and 7541 mg/L
	CAS No.	H88-55-01
Aluminum	7420005	97.0
Calcium	7440430	430.0
Chromium	2440473	15.0
Copper	7440508	4.1
fror	7439896	520.0
Leed	1430021	=======================================
Megnesium	7439054	0.00
Manganese	7430005	3.7
Nickel	7440020	17.0
Zinc	7440000	4.0
	* Community	
	Miscellaneous Chemoterization	noterization
Comceivity (pH) Rescrivity - Tota Releaseble/Sulfite (mg/kg)	**************************************	R960-85-01

3.6 HYDROFLUORIC ACID ALKYLATION

3.6.1 Process Description

Hydrofluoric acid alkylation is very similar to the H₂SO₄ alkylation process. In the hydrofluoric acid alkylation process, olefin and isobutane gases are contacted over hydrofluoric acid (HF) catalyst to synthesize alkylates for octane-boosting. The reaction products are separated by distillation and scrubbed with caustic. Alkylate product has a research octane number (RON) in the range of 92 to 99. Because of its clean burning and contribution to reduced emissions, alkylate is a highly valued component in premium and reformulated gasolines. The HF process differs from the H₂SO₄ alkylation in that the HF catalyst is managed in a closed-loop process, never leaving the unit for replacement or regeneration. Figure 3.6.1 provides a generic process flow diagram for HF alkylation.

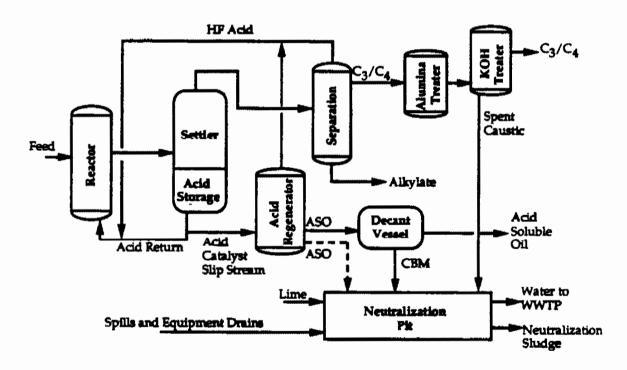


Figure 3.6.1. HF Alkylation Process Flow Diagram

The olefin stream is mixed with the isobutane and HF in the reactor. To prevent polymerization and to receive a higher quality yield, temperatures for the HF catalyzed reaction are maintained at approximately 100°F. Pressures are kept so all reaction streams are in their liquid form (usually 85 to 120 psi). The streams are mixed well in the reactor to allow optimum reaction to occur.

The hydrocarbon/acid mixture then moves to the settler, where it is allowed to settle and phase separate. The hydrocarbons are drawn off the top and sent to a fractionator. The acid is drawn from the bottom and recycled back to the reactor. A slip stream of acid is sent to an acid regenerator where distillation separates the

U.S. alkylation units are operating at more than 90% of the 1,083,154 BPSD capacity from 103 refineries (59 of which used HF alkylation), according to an Arthur D. Little report.

HF acid from by-product contaminants. The HF acid from the regenerator is recycled back to the reactor. Fresh acid is added to replace acid losses at a rate of about 500 pounds per day.

A residual of high molecular-weight reaction by-products dissolves in the HF acid catalyst and lowers its effectiveness. To maintain the catalyst activity, a slip stream of catalyst is distilled, leaving the by-product, acid soluble oil (ASO), as a residue. The ASO is charged to a decanting vessel where an aqueous phase settles out. The aqueous phase, an azeotropic mixture of HF acid and water, is referred to as constant boiling mixture (CBM). The ASO is scrubbed with potassium hydroxide (KOH) to remove trace amounts of HF and either recycled, sold as product (e.g., residual fuel), or burned in the unit's boiler. The CBM is sent to the neutralization pit. In some cases, the ASO from the regenerator is sent directly to the neutralization pit. The ASO is a residual of concern for the petroleum refining study.

A series of fractionators distills the feed streams from the reactor into the alkylate, saturated gases, and HF acid. The isobutane and HF are recycled back into the reactor as feed.

The main fractionator overhead is charged to the depropanizer and debutanizer, where high-purity propane and butane are produced. The propane and butane are then passed through the alumina treater for HF removal. Once catalytically defluorinated, they are KOH-treated and sent to LPG storage.

As HF is neutralized by aqueous KOH, soluble potassium fluoride (KF) is produced and the caustic is eventually depleted. Some facilities employ KOH regeneration. Periodically some of the KF-containing neutralizing solution is withdrawn to the KOH regenerator. In this vessel KF reacts with a lime slurry to produce insoluble calcium fluoride (CaF₂) and thereby regenerates KF to KOH. The regenerated KOH is then returned to the system, and the solid CaF₂ is routed to the neutralizing pit. The KF, at facilities that do not have a regenerator, is sent directly to the neutralizing pit, where it is reacted with lime to form a sludge.

Spent caustic, KOH scrubbers, acidic waters from acid sewers and, in some cases, CBM are charged to neutralization pits (in-ground tanks), which neutralize effluent to the WWTP. Neutralizing controls fluoride levels to the WWTP. Neutralizing agents (sodium, calcium, and potassium hydroxide) are selected based on the refineries' WWTP permits.

Effluent to the pit is neutralized, generally with lime, which forms a sludge (calcium fluoride) that collects on the bottom of the pit. This sludge is a residual of concern for the petroleum refining listing determination.

HF acid is an extremely corrosive and toxic chemical. Refineries go to great lengths to protect their personnel from coming in contact with HF. Prior to entrance to an HF alkylation unit, personnel must have special training and wear various levels of personal protective clothing (depending upon the work to be performed). The unit is generally cordoned off and marked as an HF hazard area. Valves, flanges, and any place where leaks can occur are painted with a special paint that will change colors when contacted with HF. The units are continuously monitored and alarms are activated if an HF leak is detected.

3.6.2 Sludge from Hydrofluoric Acid Alkylation - Residual 12

3.6.2.1 <u>Description</u>

As discussed above, the volume and type of sludge generated are dependant on the types of influents to the neutralization pit and the type of neutralizing agent used. Neutralizing agents are selected based on the fluoride limits in the WWTP permits. Generally, lime is used, creating calcium fluoride salts. The fluoride salts drop to the bottom of the pit and form a sludge, which periodically must be removed.

KOH scrubbers produce potassium fluoride, which is soluble. It is sent to the regenerator, as discussed above, or charged to the neutralization pit where it is contacted with lime. The calcium fluoride salt settles out, forming a sludge, and the resulting KOH solution is discharged to the WWTP. Some facilities discharge ASO or CBM to their neutralization pit, which adds heavy hydrocarbons (i.e., alkylation process tars) to their HF sludge.

The neutralization sludge, composed largely of calcium fluoride and unreacted lime, is removed on a batch basis approximately every 3 to 6 months. The sludge is usually removed using a vacuum truck. It may be dewatered using either a centrifuge, belt press, or plate and frame filter press prior to final management.

Seven HF sludge residuals were reported as being managed as hazardous. These residuals were managed as either F037, K051, ignitable and corrosive, or corrosive.

3.6.2.2 Generation and Management

The refineries reported generating approximately 11,288 MT of HF alkylation sludge in 1992. Residuals were assigned to be "HF alkylation sludge" if they were assigned a residual identification code of "alkylation neutralization sludge" and was generated from a process identified as an HF acid alkylation unit. This corresponds to residual code 02-B in Section VII.2 of the questionnaire and process code 09-B in Section IV-1.C of the questionnaire. Table 3.6.1 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.6.1. Generation Statistics for HF Alkylation Sludge										
Final Management	unagement # of # of Total Average Volume Per Volume (MT) Volume Streams									
Discharge to WWTP; discharge to surface water	3	1	78.6	26.2	28					
Onsite land treatment	5	1	556	111	542					
Offsite land treatment	1	0	686	686	686					
Disposal offsite Subtitle D landfill	7	1	7,374.4	1,053.5	1,977					
Disposal onsite Subtitle D	1	0	45	45	4.5					
Disposal offsite Subtitle C landfill	4	1	61	15	39					
Disposal onsite surface impoundment	1	0	221	221	221					
Offsite industrial furnace ²	1	0	828	828	828					
Recovery onsite in coker	_ 1	0	1,314	1,314	1,314					
Neutralization	2	0	124	62	124					
Total HF alkylation sludge	26	4	11,288	342	1,314					

¹ Surface impoundment dedicated to alkylation unit; practice discontinued in 1992.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.6.1 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

- Onsite land treatment (5% of sludge)
- Offsite Subtitle D landfilling (about 65% of sludge)
- Onsite Subtitle D landfilling (about 0.4% of sludge)

² Waste sent to cement kiln (applying for BIF status); refinery since closed.

An onsite monofill scenario was rejected because of the intermittent generation frequency, which is not typical of waste that tends to be monofilled. Similarly, on-site interim storage was not modeled. The sludge is generated infrequently, and space and cost constraints create incentives for the refineries to minimize the on-site storage period.

The sludges managed in wastewater treatment systems were not chosen for evaluation in the risk assessment because these sludges will settle out in the primary treatment steps and are already listed as hazardous.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.6.2.

Table 3.6.2. Selection of Risk Assessment Modeling Scenario: HF Alkylation Sludge								
Waste	Basis for Consideration in Risk Assessment							
Discharge to WWTP; discharge to surface water	Not modeled. Minimal volume. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be captured by existing hazardous waste listings and further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.							
Onsite land treatment	Modeled							
Offsite land treatment	Modeled							
Disposal offsite Subtitle D landfill	Modeled							
Disposal onsite Subtitle D landfill	Modeled							
Disposal offsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control							
Disposal onsite surface impoundment	Not modeled, rare practice and unit closed in 1992							
Offsite industrial furnace	Not modeled; rare practice; cement kiln managing hazardous waste and presently applying for BIF permit, and refinery reporting this practice is now closed							
Recovery onsite in coker	Not modeled, management practice expected to be exempt							

Characterization data for the management units and their underlying aquifers were reported in the §3007 survey. Table 3.6.3 provides a summary of the data for the targeted management practices used in the risk assessment.

Table 3	Table 3.6.3. Management Practices Targeted for Risk Assessment										
HF Alkylation Sludge											
Parameters	# of Fac.	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1									
Onsite and Offsite Subtitle D Landfill ^{1,4}	6	8	1	7,374.5		1,448	2,256.6				
			Onsite	Landfill Chara	eteristics		***************************************				
	Surface .	Area (acres)	***		7	7	7				
	Remaini	ng capacity (cu.yd.)		75,000	75,000	75,000				
	Percent :	remaining ca	pacity (cu.yd.)		13	13	13				
	Total cap	pacity (cu.yd.	.)		150,000	150,000	150,000				
	Number	of strata in c	ompleted unit			_	_				
	Depth be	low grade (f	i)		3	3	3				
	Height a	bove grade (i	ft)		5	5	5				
	# of Lan	dfills: 1				·····					
			A	quifer Informa	tion						
	Depth to	Aquifer (ft)	***************************************		15.5	15.5	15.				
	Distance	to Private W	/ell (ft)		16,000	16,000	16,000				
	Populatio	on Using Priv	rate Well		_	_	_				
	Distance	to Public W	ell (ft)			-					
	Populatio	on Using Pub	lic Well								
	# of Aqu	ifers: 1			P(A,-,,) /- /- ASS - A						
·	Uppermo Lowerme	Source: Public Private Unreported 1 — Uppermost — — Lowermost — — Combination — 1									
			ermost Aquifer: red a potential sou	rce of drinkin	g water (1)						

Table :	Table 3.6.3. Management Practices Targeted for Risk Assessment											
HF Alkylation Sludge												
Parameters	# of Fac.											
Offsite Land Treatment Unit	1	1	0	686	_	686	686					
Onsite Land Treatment Unit ^{1,3}	4	5	1	556	-	6.35	542					
realment Onli				Characteristic	s	, , , , , , , , , , , , , , , , , , , ,						
	Surface .	Area (acres)		•	0.6	7	32.3					
	Depth of	Incorporation	on (in)		4	12	60					
	Amount	Applied (199	2 MT) ²		2	229	1,049.5					
	Methods	of Incorpora		Subsurface Inje Bulldozing (1)	etion (1)							
	# of Lan	d Treatment										
			A	quifer Informa	tion 	r						
	Depth to	Aquifer (ft)			15.5	60	150					
	Distance	to Private V	Veli (ft)		2,000	6,200	26,400					
	Population	on Using Pri	vate Well		1	2	3					
	Distance	to Public W	'ell (ft)		2,000	10,240	18,480					
	Population	on Using Put	lic Well		250	250	250					
	# of Aqu	ifers: 6										
	Lowerm											
	Classific	Current or p	ermost Aquifer: octential source of red a potential sou									

The mean and/or 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

² Volumes represent the average volume of all wastes applied to the land treatment units accepting the HF acid alkylation sludge and not just the sludge alone.

³ The number of onsite land treatment units characterized in Table 3.6.3 is greater than indicated in Table 3.6.1 which focuses only on volumes generated in 1992. Table 3.6.3 incorporates data from all onsite land treatment units receiving HF acid alkylation sludge in any year reported in the §3007 survey.

⁴ Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.6.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.6.4 summarizes the physical properties of the tank sludge as reported in Section VII.A of the §3007 survey.
- Five samples of HF alkylation sludge were collected from the neutralization pits. These sludges represent the various types of dewatering typically used by the industry. Table 3.6.5 presents sample locations and descriptions.

Table 3.6.4. HF Alkylation Sludge Physical Properties										
Properties	Mean	90th %								
pН	31	16	7.5	10.27	12.6					
Reactive CN, ppm	16	31	0	19.9	50					
Reactive S, ppm	14	33	0	26.2	100					
Flash Point, °C	14	33	60	83.65	100					
Oil and Grease, vol%	13	34	0	2.68	5					
Total Organic Carbon, vol%	8	39	0	3.41	10					
Specific Gravity	15	32	1.1	1.18*	1.6					
BTU Content, BTU/lb	2	45	100	1,050	2,000					
Aqueous Liquid, %	34	13	0	54.6	90					
Organic Liquid, %	27	20	0	1.44	5					
Solid, %	35	12	10	49.4	100					

^{*} Used the 50th percentile because the arithmetic mean was higher than the 90th percentile due to an erroneous data point.

Samples of HF alkylation sludge were collected from the neutralization pits. Five samples were collected: four samples were dredged from the pit (not dewatered) and 1 sample was collected after it had been filter pressed (dewatered). The samples are believed to be representative of the sludge as generated. One of the dredged samples was dewatered by the laboratory prior to analysis at the request of the refinery to represent their "disposed" sludge. Table 3.6.6 provides a summary of the characterization data collected under this sampling effort. Only constituents detected in at least one sample are shown in this table. As presented in the data, 4 of the HF sludge samples exhibited the characteristic of corrosivity. High concentrations of calcium and sodium can be attributed to the neutralizing agents: lime, calcium hydroxide and sodium hydroxide.

Table 3.6.5. HF Alkylation Sludge Record Sampling Locations								
Sample Number	Location	Description						
R3-HS-01	Exxon, Billings, MT	Dredged from neutralization pit						
R8B-HS-01	Amoco, Texas City, TX	Dredged from neutralization pit						
R9-HS-01	Murphy, Superior, WI	Dredged from neutralization pit						
R15-HS-01	Total, Ardmore, OK	Dredged from neutralization pit						
R7B-HS-01 BP, Belle Chasse, LA Filter pressed								

3.6.2.4 Source Reduction

As described in the H₂SO₄ alkylation section, several solid-acid catalysts used for alkylation are being tested in pilot plants. The reactor systems are different from the current liquid-acid systems, but for one system the other equipment is compatible. Three types of the new solid catalyst include aluminum

According to Oil and Gas Journal, solid-acid alkylation units are expected to have the greatest impact on HF alkylation capacity.

chloride, alumina/zirconium halide, and antimony pentafluoride (a slurry system).

Recycling methods for the calcium fluoride include use in the steel-manufacturing industry. The calcium fluoride can be used as a neutral flux to lower the slag-melting temperature and to improve slag fluidity. CaF₂ can also be routed back to an HF acid manufacturer, as the basic chemical in the HF-manufacturing process, which is the reaction of H₂SO₄ with fluorspar to produce hydrogen fluoride and calcium sulfate (Meyers).

One refinery changed its neutralization pit from an in-ground tank to an above-ground tank to segregate the ASO from entering the pit and to prevent dirt and spilled hydrocarbons from contaminating the CaF₂. Their goal was to find a market to recycle the calcium fluoride. As of August 1994, the refinery had not found a market for the CaF₂ and was landfilling it.

Table 3.6.6. HF Alkylation Sludge Characterization

				VI -42 /2		. MARINEC	CIMPLIFIC	terization			
										00% Contidence	
	Volatile Organice	 Method 8260/ 	uaka 🗀						,	Interval	
	CAS No.	R3-HS-01		R9-HS-01	R15-HS-01	R7C-H8-0:	Average Cove	Meximum Conc	Std Dev	Upper Umit	Commente
Acetone	67641	< 12.500	8,300	15,000	2,500	6,100	9,140				ССППИИ
Benzena	71432							10,000	\$,208	12,710	
	1	J 6,100	14,000	< 625		< 650	4,336	14,000	5,017	8,394	
Chlorobenzene	108907	< 12,500	1,800	< 625		< 650	847	1,630	654	1,382	1
n-Bulyiberzene	104518	< 12,500		1,900	≺ 313		627	1,930	727	1,422	1
Crotonaldehyde	4170303	82,000	< 825	< 625	< 313	< 650	16,840	82,000	36,424	41,814	
sec-Butylbenzene	135988	J 20,000	< 525	< 625	J 290	< 650	4,436	20,000	6,701	10,403	
ten-Butytbenzere	98066	< 12.500	< 625	< 625	J 680	J 560	623	580	49	663	1
Ehvibenzene	100414	73,000		J 770		J 750	15,101	73,000	32,367	37,201	•
legrapy@anzene	95628	J 14.000				< 650	3,243	14,000	6.015	7,360	
p - ladpropytrolugne	99575	J 13,000		< 625	1	< 650		,	.,		
							3,040	13,000	5,568	5,560	
Mathyl athyl ketone	78933	< 12,500		-,;	< 313	2,100	1,606	3,400	1,426	2,777	1
n-Propylbanzeru	103651	67,000			< 313	J 560	13,640	67,000	20,713	34,210	
Toluane	108883	65,000		J 1,100	J 740	J \$90	17,531	65,000	37,718	43,369	
1,2,4—Trimethylbenzene	95838	400000	< 625	12,000	2,500	2,700	101,166	488,000	214,293	240,451	
1,3.5 Trimmthytomzene	108678	143,000	< 625	6,700	J 1,000	J 1,000	30,465	143,000	62,960	73,620	
o-Xylene	95476	127,000	< 525	1,800	J 220	J 410	25,971	127,000	58,479	64,692	
m p - Xylenes	108383/108423	352,000		3,700		J 1,200	71,597	352,000	154.755	179.065	
Nachthalene	91203	37,000		1,400			8,064	37,000	16,181	,	
stafate (market	1 230	37,000	0201	1,44,	2 213/2	B 900	8,004	37,00	15, 101	19,157	
										90% Conlidença	
	TCLP Volatile Org				_					Interval	
	CAS No.	R3-H3-01	R6B-HS-01	R9-HS-01	A15-HS-01			Meximum Cosc	Std Dev	Upper Limit	Commente
Acetone	67641	< 50	760	1,300	,	3 530	584	1,300	485	917	
Benzene	71432	160	< 50	< 50	< 50	< 50	76	160	58	110	
Etry benzene	100414	B 530	< 50	< 50	< 50	< 50	146	530	215	293	
n-Propytherizene	103651	120	< 50	< 50	< 50	< 50	64	120	31	85	
Toluene	108883		< 50	1	1	< 50	280	1,200	514	633	
Mathylane chloride	75092	< 50	2,000		< 50	270					
							548	2,000	B24	1,113	
Methyri ethyl kelcine	78933	< 50	J 76	200		150	105	20G	67	151	
1,2,4—Trimethylbimzene	95838	1,300	< 50		< 50	c 50	300	1,300	559	683	
1,3,5—Trimethythenzene	108678	1,100				< 50	2 6 0	1,100	470	582	
o-Xylane	95476	B 1,100				< 50	2 6 0	1,100	470	582	
mp-Xylene	108383/108423	B 480	< 50	< 50	< 50	< 50	136	460	192	268	
Nashibalane	91203	450	< 50	< 50	< 50	6 23	127	460	187	255	
	,									,	
										90% Contidence	
	Semivolatile Orga	nics - Method	A2709 unAn							Internet	
	CAS No.	R3-HS-01		R9-HS-01	F115-HS-01	B7C_US_M	Avenue Cons	Maximum Care	Stc Dev	Upper Limit	Comments
Dh.D. athultum dahahalata	117017	J 2,100									COmmercia
Bb(2-sthythaxylighthalale					-1	< 165	1,332	2,100	930	2,004	1
Flucrene	66737	J 2,900			. =====	< 165	1,532	2,900	1,198	2,513	1
Indene	95136	J 3,300	,	-, -, -, }	_,_,_	< 165	1,632	3,300	1,358	2,743	1
Phanamikeme	85018	J 4,500			< 2,083	2,400	2,491	4,500	1,480	3,602	1
Phenoi	108952	120,000	< 1,000	< 5,157	< 2,063	< 165	25,677	120,000	52,762	51,849	
1 - Mathylnaphthalane	90120	98,000	< 2,000	< 10,313	< 4,125	3,000	23,488	98,000	41,779	52,131	
2-Mathylmaphthalene	91576	180,000			< 2,063	5,400	38,724	180,000	78,999	92,664	
2-Methylphenol	95467		< 1.000		71	< 165	4,877	16,000	€ 490	9,332	
3/1 - Mathytphenol (total)	NA NA	32,000		< 5,157		< 165	8,077	32,000	12,500	17,337	
Nachthalere	91203	110,000				2.000			, 1		
urdan material	1 9120	134,000}	1,000	J 4,800}	· 2,003	2,000	23,973	110,000	48,112	\$6,967	

HF ALKYLATION BLUDGE

									(10% Confidence	
	TCtP Semivolatile	o Organics Ma	thads 1311 and	. الروبر 6270B بورا.						Interval	
	CAS No.	R3~H3-01			R15-H9-01		Average Conc	Meximum Cano	Std Dev	Upper Limit	Comments
Bis(2 – ethythexyl)phthelet .	117817						12	13	2	13	1
Di-n-bulyiphthalate	84742		< 50			B 120	84	120	31[85	
2.4—Dimethylphenol	105879	, , ,	< 50			< 50	54	71	9	61	
2-Methylphenol	95467	630			< 50	< 50	200	630	349	445	
3/4 - Methylphenol (Ictel)	NA I	1,200	< 50	< 50	< 50	< 50	280	1,200	514	633	
1 - Methylmaphthalane	90120	J 97	< 100	J 21	< 100	J 19	46	97	44	94	1
2-Methylmaphthelene	91576	160	< 50	< 50	< 50	J 28	66	160	63	104	
Nachthalans	91203	320 -			< 50	J 22	96	320	124	184	
Phenal	108952	4,100	c 50	< 50	< 50	< 50	860	4,100	1,811	2,102	
Indene	95 136	J 12	< 50	< 50	< 50	< 50	12	12	NA	NA	1
]									90% Confidence	
				7471, and 7841 m						interral	
	CAS No.	R3H9-01	R68-H3-01	R9-HS-01	A15~HS-01			Maximum Carc	Std Dev	Upper⊔mit	Comments
Alimhum	7429905	4,400.0	23.0	980.0	1,500.0	6,000.0	2,580.€	8,000.0	2,\$13.6	4,303.9	
Antmony	7440360		< 0.3	- 0.0	< 0.0	30.0	9.7	30.0	11.6	17.0	
Amenic	7440382	6.7	0.2	< 1.0	< 5.0	5.3	3.4	5.7	2.6	5.2	
Berlum	7440393	85.0				< 20.0	29.2	0.56	32.3	51.3	
Calcium	7440702	76,000.0	35,000.0	67,000 G	130,000.0	200,000.0	105,600.0	200,0000	62,676.2	144,569.4	
Chromium	7440473	59.0	0.1	2.4	4.2	3.6	13.0	59.0	25.3	31.2	
Cabalt	7440484	7100		< 6.0	< 5.0	5.0	145.1	7100	215.6	361.6	
Capper	7440508	300.0	0.7	84.0	22.0	14,0	84.1	3000	124.6	169.7	
tron	7439896	26,000.0	26.0	720.0	2,200.0	570.0	5,903.2	26,000.0	11,253.3	19,625.1	
Lead	7439921	1100		1.7	0.0	0.9	22.7	1160	40.6	50.2	
Magnesium	7439954	3,700.0	83.0	1,100.0	1,200.0	< 500.0	1,316.6	3,700.0	1,408.0	2,261.0	
Manganese	7439965	150.0	1.0	33.0	34.0	8.7	51.3	1860	73.4	101.7	
Nickel	7440020	730.0	4.1	220.0	78.0	57.0	217.8	7300	297.2	421.6	
Potessium	7440097	4,100.0		< 500.0	34,000.0	< 500.0	7,625.0	34,000.0	14,723.5	17,910.3	
Salanium	7762492	5.6			< 0.5	< 0.5	1.4	5.0	2.3	3.0	
Sodium	7440235	0,000.0	19,000.0	4,100.0	4,300.0	14,000.0	10,000.0	19,000.0	0,447.1	14,420.0	
Venedium	7440622	10.0			< 5.0	16.0	0.5	10.0	7.2	13.4	
Zho	7440060	130.0	< 1.1	7.5	0.7	13.0	31.7	130.0	55.1	69,5	
									,	90% Contidence Interval	
				7470, 7471, and		DTO 410 04	A	Maulanian Con	Std Dev	Upper Limit	Comments
	CAS No.	R3-HS-01	R&B-HS-01		R15-HS-01			Maximum Canc 5.20	1.88	3,13	Comments
Aluminum	7429905					5.20	1.84	0.32	D. 14	0.46	
Anthrony	7440360	< 0.30			< 0.30	0.62	0.36 529.00	2000.00	855.51	1115.52	
Calcium	7440702	570.00				2,000.00	0.29	0.73	0.26	0.47	
Copper	7440508	< 0.13		0.73	0.33	< 0.13		3.70	1.54	2.68	
tron	7439896	3.70			2.80	< 0.50 0.32	1.60 0.36	0.71	0.30	0.57	
Mengenese	7439965	0.71			0.64		1.17		1.75	2.37	
Nickel	7440020	< 0.20	0.40	0.46	4.30	0.50		1600.10	892.50	839.77	
Polasskam	7440097		< 25.00		.,	< 25.00	365.00		0.10	0.41	
Zha	7440666	0.31	0.45	0.22	0.41	0.30	0.34	1 0.401	0.10	0.411	

Comments:

Detection limits greater than the highest detected concentration are excluded from the calculations.
Upper Limit exceeds the maximum concentration.

10,000.0

RMB-HS-01

NA NA

Miscelline ous Characterization

- B Analyte also detected in the associated method blank.
- Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the lab cratory detection limit, but greater than zero.

Pege 2

9,000,0

R9-HS-01 R15-HS-01 R7C-HS-01 Average Conc Maximum Conc

1.0

4,790.4

10,000.0

- NO Not Detected.
- NA Not Applicable.

R3-HS-01

14

160.0

90% Confidence Interval

Upper Limit

0,257.1

Comments

Std Dev

5,453.9

Conceivity (pH)

Total Fluorine (mg/kg)

3.7 THERMAL PROCESSES

3.7.1 Process Description

Thermal processes include all processes where feed is cracked solely by a thermal process, rather than a catalytic reaction mechanism. Like catalytic cracking processes such as FCC, thermal processes convert heavy stocks to light hydrocarbon products such as gasoline blending stocks. Unlike the FCC, however, thermal processes crack without a catalyst. The RCRA §3007 database identifies 64 facilities with thermal cracking processes, as follows (the total exceeds 64 because some facilities have multiple types of thermal processing units):

Process	Number of Facilities
Delayed coking	47
Visbreaking	10
Fluid coking	7
Thermal cracking	4
Coke calcining	2

3.7.1.1 Delayed Coking

A process flow diagram of a delayed coking unit is shown in Figure 3.7.1. Residuum is heated to the point of cracking, 900 to 950°F, and is continuously fed to a coke drum at 20 to 60 psi in the delayed coking unit (McKetta, 1992). The residuum cracks in the drum; the gaseous products exit the top of the drum and are recovered in the fractionation section. Coke, a product of the cracking process, slowly builds up in the drum.

After approximately 24 hours, the coke drum fills with coke and the feed is switched to a parallel coke drum. The first drum is cooled and the built-up coke is hydraulically drilled out onto a pad and sold as a product.

The drilling cycle typically is as follows:

- 1. Feed to the coke drum is stopped.
- 2. The coke drum is depressurized and cooled; the offgases are vented to the recovery section.
- 3. The coke is drilled out using high pressure (3000 psi) water (McKetta, 1992).

Due to these repeated drilling cycles, the delayed coking process is a high consumer of water. Present refinery practice, however, includes the recycling of this water within the unit. To prepare the water for reuse and to collect additional coke product, the water is typically treated using gravity separation to remove fines. These fines are collected and typically mixed with the coke product.

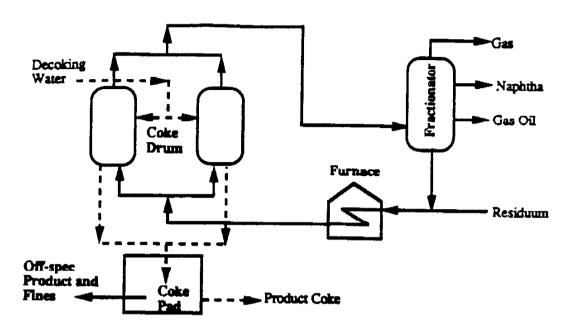


Figure 3.7.1. Process Flow Diagram of Delayed Coking Unit

3.7.1.2 <u>Visbreaking</u>

The visbreaking process operates under less severe conditions than a coking process (850 to 900°F, 200 to 500 psi). Unlike delayed coking, the principal objective is not to produce gasoline blending stocks but instead to produce gas oil for use in heating oils. Residuum is fed to the reactor, where the feed is cracked and the overhead gases fractionated. Because the process is less severe, visbreaking units do not generate product coke or fines.

3.7.1.3 Thermal Cracking

Like visbreaking, thermal cracking operates under less severe conditions than delayed coking. Feed to the unit includes residuum and gas oils. The reaction is conducted at approximately 1000°F and 140 psi (Leffler, 1985). These conditions allow the heavier molecules to crack but prevent coke formation. A fractionator separates the products which include residual fuel oil, gasoline, and light gases such as butane. The Dubbs unit is a thermal cracking unit.

3.7.1.4 Fluid Coking

A process flow diagram of a fluid coking unit is shown in Figure 3.7.2. All fluid cokers presently operated in the U.S. are licensed by Exxon under the name fluid coking or flexicoking. Residuum is heated and pressurized to be continuously fed to a fluidized bed reactor. The process uses no catalyst. Rather, the reactor bed consists of fluidized coke fines. The residuum cracks in this reactor to form lighter hydrocarbons which are recovered overhead in a fractionator. Additional coke is formed from the reaction and is continuously removed from the bottom of the unit, where it is used as fuel for the unit or is sold as product.

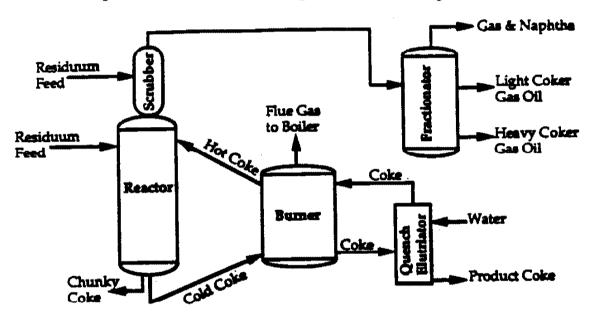


Figure 3.7.2. Process Flow Diagram of Fluid Coking Unit

3.7.1.5 Coke Calcining

Facilities with delayed coking units may further process their coke in a calciner to upgrade the product. A calciner dries the material and removes volatile organic compounds. However, calcining was not considered part of the scope of this refining industry study because it is not inherent to the refining process.

October 31, 1995

3.7.2 Off-spec Product and Fines from Delayed Coking - Residual 13

3.7.2.1 <u>Description</u>

Of the five processes described above, only two generate RCs for this study:

- The delayed coking process generates product coke. When drilled out of the coke drum, the sizes of coke chunks range from 1 foot to one millimeter. The larger chunks are typically easily transferred to a coke product storage area, such as a pile. The smaller particles may become entrained in the coker unit water and are separated out by gravity, screening, or other physical separation processes. Fines may also appear near conveyer equipment. Some refineries do not distinguish fines from other coke product if they collect all of the coke in one storage area for sale. Most product, including fines, is sold as coke. Occasional product spillage results in the generation of off-spec product.
- The fluid coking process also generates product coke. Unlike the delayed coking process, the product is limited to fine, fluid-like particles. Larger agglomerated particles are sometimes formed and are removed from the system.

None of the other processes generate product coke, and therefore none generate "off-spec product" for the purposes of this listing determination. The only solid residuals typically generated from these processes are reactor clean-out wastes. These are likely to resemble coked particles and scale, and could not be considered "fines." Therefore, no other RCs are generated from thermal processing.

Approximately 744 MT of off-spec product and fines from thermal processes generated in 1992 were identified as displaying hazardous characteristics; less than 1 percent of the total volume managed.

1992 Identification of Off-spec Product and Fines from Thermal Processes

Total managed as hazardous (no specific designation): 744 MT

3.7.2.2 Generation and Management

Based on observations from engineering site visits, off-spec or fine coke from delayed coking is most often combined with other product coke for onsite interim storage in large piles.

Forty-four facilities reported generating a total quantity of 194,262 MT of this residual in 1992, according to the 1992 RCRA §3007 Questionnaire. Residuals were assigned to be "off-spec product and fines from thermal processes" if they were assigned a residual identification code of "off-spec product" or "fines" and were generated from a thermal process. These correspond to residual codes 05 and 06, respectively, in Section VII.2 of the

questionnaire and process code 14 in Section IV-1.C of the questionnaire. Based on the results of the questionnaire, 53 facilities have delayed or fluid cokers and thus may generate off-spec or fine coke. The other 9 facilities likely either (1) did not generate a separate fines stream in 1992, or (2) combine all of their coke product, including fines, in one pile and did not account for size differences. Table 3.7.1 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on both (1) the Agency's past experience with risk assessment modeling in identifying pathways of greatest concern, and (2) actual management practices used to manage this residual in 1992. Based on these two selection criteria, the following management practices from Table 3.7.1 were identified as those likely to pose the greatest threats to human health and the environment:

- Offsite Subtitle D landfill (used for 3.6 percent of the total residual volume).
- Onsite Subtitle D landfill (used for 0.1 percent of the total residual volume).

The predominant management method, offsite sales, was not evaluated because of the difficulty of modeling exposure pathways from this non-petroleum refining industry. Based on observations from engineering site visits, off-spec or fine coke is most often combined with other coke onsite in a pile. EPA assessed risks only from waste management, not product storage. However, EPA did assess the potential for air releases during landfilling as a result of the frequent generation frequency and small particle size associated with this residual and believes that this assessment may be comparable to the potential risks associated with on-site storage prior to final management.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.7.2.

The management unit characterization data were provided in the §3007 survey. Table 3.7.3 provides a summary of the management unit characteristics and aquifer information.

3.7.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.7.4 summarizes the physical properties of the tank sludge as reported in Section VII.A of the §3007 survey.
- Six record samples of off-spec product or fines were collected and analyzed by EPA. These samples represent residuals generated from the two different types of units generating this residual and are summarized in Table 3.7.5.

Table 3.7.1. Generation Statistics for Off-Spec Product and Fines from Thermal Processes, 1992 90th % Final Management # of with Total Average # of Volume Streams unreported Volume Volume volume (MT) (MT) (MT) 9 Transfer with coke producti 38 168,986 4,447 17,000 Recovery onsite in coker² 2 1 9.358 4.679 9.125 Disposal in offsite Subtitle D landfill 11 0 7,064 642 441 Discharge to onsite WWTP² 6 4.996 833 3,200 1 3 2,088 696 2.000 Onsite boiler² 1 11 0 786 71 211 Disposal offsite in Subtitle C landfill 8 1 399 50 196 Onsite storage³ 0 200 200 200 Offsite recycle to catalyst broker 1 Disposal in onsite Subtitle D landfill 0 187 164 3 62 0 70 Disposal in onsite Subtitle C landfill 2 140 70 2 34 34 1 34 Onsite land treatment 0 21 21 Offsite land treatment 1 21 Offsite incineration 2 0 3 1.5 1.5 5 0 0 0 Other4 1 5,372 TOTAL 90 20 194,262 2,158

¹ Management methods reported as "offsite use as fuel" and "transfer with coke product" were combined here because they were assumed to be the same.

² The facilities reporting the residual comprising the largest (90th percentile) volumes for using these management methods verified their management methods as follows:

[•] Onsite recovery in coker: offgas from fluid coking is sent to a CO boiler, then to an electrostatic precipitator (ESP). Fines from the ESP are recycled to the unit feed.

[•] Discharge to onsite wastewater treatment: Water discharged from the battery limits of this facility's delayed coking unit contains fines, which settle as primary sludge in their treatment system.

[•] Onsite boiler: offgas from fluid coking is sent to a CO boiler. Fines, present in the flue gas at the quantity indicated, are burned in this boiler.

^{&#}x27;Storage onsite in piles and in roll-on/roll-off bins was reported as final management method; ultimate management was not provided.

⁴ Other interim management practices were included, with no effect on total volume, a small effect on 90th percentile, and only a one percent effect on mean volume.

	Table 3.7.2. Selection of Risk Assessment Modeling Scenario: Off-Spec Product and Fines from Thermal Processes								
Final Management	Basis for Consideration in Risk Assessment								
Transfer with coke product ¹	Not modeled, exempt management practice								
Recovery onsite in coker ²	Not modeled, exempt management practice								
Disposal offsite in Subtitle D landfill	Modeled								
Discharge to onsite wastewater treatment ²	Not modeled. Fines would settle out in sludge and be captured by existing hazardous waste listings. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.								
Onsite boiler ²	Not modeled, boiler is integral part of fluid coker (designed to control CO releases, not fines) and is not comparable to typical industrial boiler								
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control								
Onsite storage ³	Not modeled; small volume and not final management practice								
Offsite recycle to catalyst broker	Not modeled, exempt management practice								
Disposal in onsite Subtitle D landfill	Modeled								
Disposal in onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control								
Onsite land treatment	Not modeled, rare practice, minimal volume; evaluated and emissions for landfill likely to be of greater concern								
Offsite land treatment	Not modeled, less than 100 mt								
Offsite incineration	Not modeled, de minimis volume								

See footnotes for Table 3.7.1.

Table 3	Table 3.7.3. Management Practices Targeted for Risk Assessment										
Off-spec Product/Fines from Thermal Processes											
Parameters	# of Fac.										
Onsite and Offsite	9	14	0	7,251		90.7	659				
Subtitle D Landfill ^{1,2}			Onsite L	andfill Char	acteristics						
	Surface A	rea (acres	s)		12.6	36	50				
	Remainin	g Capacit	y (thousand cu.ye	d .)	240	423	6,500				
	Percent R	emaining	Capacity		0.7	1	100				
	Total Car	acity (tho	usand cu.yd.)		240	564	8,000				
	Number o	of Strata i	Completed Uni	t	400	400	400				
	Depth Be	low Grade	(ft)		0	0.5	1				
	Height A	bove Grad	le (ft)		6	17	72				
	# of Lanc	Ifills: 3									
	<u></u>		Aq	uifer Inform	ation						
	Depth to	Aquifer (1	t)		16	32	166				
	Distance	to Private	Well (ft)	·····	5,280	5,280	5,280				
	Populatio	n Using P	rivate Well	······································	0	0	0				
	Distance	to Public	Well (ft)		5,280	5,280	5,280				
	Populatio	n Using P	ublic Well		-						
	# of Aqui	ifers: 3									
		Source: Public Private Unreported 3 2 Combination 1									
	C	urrent or	ppermost Aquifer potential source ered a potential s	of drinking		(2)					

¹ The 50th and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

² Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

Table 3.7.4. Off-spec Product/Fines from Thermal Processes Physical Properties									
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %				
pН	27	83	7.5	7.2	12.6				
Reactive CN, ppm	17	93	0	4.5	50				
Reactive S, ppm	20	90	0	18	100				
Flash Point, C	34	76	60	125	100				
Oil and Grease, vol%	23	87	0	7.4	5				
Total Organic Carbon, vol%	21	89	0	53	10				
Specific Gravity	43	67	1.1	1.26	1.6				
BTU Content, BTU/lb	27	83	10	18,200	2,000				
Aqueous Liquid, %	53	57	0	6.7	90				
Organic Liquid, %	49	61	0	2.4	5				
Solid, %	83	27	10	93	100				
Particle > 60 mm, %	26	84	0	12	100				
Particle 1-60 mm, %	26	84	0	40	60				
Particle 100 μm-1 mm, %	26	84	0	29	100				
Particle 10-100 μm, %	25	85	0	19	0				
Particle < 10 μm, %	24	86	0	13	0				
Mean Particle diameter, microns	12	97	0	8,545	500				

The collected samples are expected to be representative of off-spec product and fines generated in the industry. Both fines from delayed coking and off-spec product from fluid coking were collected. These are the only two processes identified that generate the residual of concern. No samples of off-spec coke from delayed coking were collected; however, the composition differences between coke, fines, and off-spec coke are expected to be small because all are generated from the same coking drum.

All six samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. None of the TCLP extracts of any of the analyzed constituents exceeded corresponding regulatory levels. No samples were analyzed for any other characteristics

(i.e., ignitability, corrosivity, reactivity); these samples were not expected to exhibit these characteristics. A summary of the results is presented in Table 3.7.6. Only constituents detected in at least one sample are shown in this table.

Table 3.7.	Table 3.7.5. Off-spec Product and Fines from Thermal Processes Record Sampling Locations								
Sample number	Facility	Description: Type of Generating Unit							
R6-TP-01	Shell, Norco, LA	Fines from delayed coking, from water settling							
R8A-TP-01	Amoco, Texas City, TX	Fines from delayed coking, from water settling							
R3B-TP-01	Exxon, Billings, MT	Off-spec product from fluid coking ("chunky coke")							
R11-TP-01	ARCO, Ferndale, WA	Fines from delayed coking, from product conveyer dust collection							
R12-TP-01 Texaco, Anacortes, WA		Fines from delayed coking, from water settling							
R14-TP-01	BP, Toledo, OH	Fines from delayed coking, from spills collected in dumpster							

3.7.2.4 Source Reduction

Some pollution prevention measures in the industry's delayed coking unit concern how to generate more, not less, of this residual. This is because most refineries blend their fines with their coke product for sale. In these cases, efforts include ways to keep the fines contained to the unit for ultimate recovery by mixing with coke product. These efforts include modifying drains or improving operations to limit the amount of fines in the water ultimately discharged to the wastewater treatment system. These fines can be collected with the product.

Table 3.7.6. Residual Characterization Data for Off-spec Product and Fines from Thermal Processes

			_								90% Confidence	
	Volatile Organics										Interval	
_	CAS No.	R6-TP-01		911-TP-01	R12-TP-01	R14-TP-01	R38~TP-01	Average Conc	Maximum Conc	Std Day	Upper Limit	Comments
Benzena	71432	< 5	< 25	1,500	< 625	< 23	< 825	407	1,500	587	82:	
n-Butytoenzene	184518	< 5	62	< 625	2,200	J 18	< 825	593	2,200	830	1,098	
Ethybenzene	100414	< 5	J 25	< 625	J 810	< 23	< 625	352	810	373	571	
p-inopropykoluena	99876	< 5	J 38	< 625	J 1,000	< 23	< 825	386	1,000	422	640	
n-Propyibenzene	103651	< 5	< 25	< 625	J 1,200	< 23	< 625	457	1,200	486	710	
Toluene	106883	< 5	J 10	2,600	< 625		< 525	683	2,800	1,070	1,333	
1,2,4-Trimethybenzene	95636	< 5	270	< 625	6,200	63	< 525		8,200	3,229	3.577	
1,3,5-Trimethybenzene	108678	< 5.	140	< 625	2,000		< 825		2,900	1,104		
o-Xylene	95476	< 5	63	< 625	2,500		< 825		2,500		1,386	
m.p-Xylenes		< 5	93	1,600	3,200	- }		ř .	1	957	1,217	
Naphthalene	91203	-							3,200	1,271	1,500	
Leafh I (Lesses III)	91203	< 5	Sun!	1,400	3,800	71	< 525	1,030	3,800	1,450	1,003	
											93% Confidence	
	TCLP Volatile On										Intervat	
	CAS No.	RO-TP-01		R11-TP-01	912-TP-01		P1361 - TP - 01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Commenta
Methylene chioride		< 50		<' 50		1		140	340	138	222	
Methyl ethyl letone	78933	< 50	< 50	< 50	< 50	250	< 50	83	250	82	133	
										·	90% Confidence	
	Semivolatile Orga	nine - Mathod R	270B ranka							Į.	inierval	
	CAS No.	R8-TP-01		A11-TP-01	312-TP-01	R14-TP-01	R38 – TP – 01	A	Manifester Cons	CH D		
Acenaphthene	83326	< 825			11,000				Maximum Conc	Std Day	Upper Limit	Comments
Anthracens	1	1,900					< 165	-, -	11,000	4,163	5,503	
	120127 56558			,				_,	9,400	3,308	4,854	
Benz(e)anthracere	11	28,000	8,700	15,000	J 10,000	10,000			28,000	9,208	17,526	
Benzofluoranthene (total)	NA NA	28,000		10,000	J 5,100	4,800	< 165	0,028	28,000	₽,811	14,040	
Benzo(g.h.i)perytene	191242	21,000	19,000	6,400	J 4,900	4,600	< 105	1	21,000	8,536	14,487	
Benzo(a)pyrene	50326	33,000	13,000	9,400	J 7,000	7,200	< 105		33,000	11,279	18,424	
bia (2 – Ethylhexyl)phthalate	1	< 825	< 4,125	87,000			< 105	, ,	87,000	34,670	37,241	
Carbazole	86748	8,900		J 2,400		< 1,650	< 330	3,256	0,900	2,655	5,076	1
Chrysone	218010	65 000	11,000	37,000	15,000	10,000	< 185	24,028	65,000	23,376	36,113	
Dibenz(a,h)erthracene	53703	14,000	J 3,000	8,600	J 2,600	< 825	< 165	4,532	14,000	5,154	7,837	
Dibenzofuran	132640	< 825	< 4,t25	< 1,030	J 6,400	< 828	< 185	2,228	đ,400	2,475	3,720	
7,12-Dimethylbenz(a)anthracene	57976	< 625	< 4,125	< 1,030	< 6,157	1 1,200	< 185	805	1,200	453	1.176	1
Fluoranthene	208440	3,600	< 4,125	J 2,000	J 4,300	1,200	< 185	2,565	4,300	1.700	3,500	
Fluorene	86737	J 900	< 4,125	< 1.030	14,000	550	< 185		14,000	5,354	6,688	
Indenc(1,2,3-cd)pyrene	193395	6,200		- 1	< 5,157		< 105		0,200	2.356	4,427	
Phononthrone	85018	10,000		4,700	58,000	3,100			58,000	21,867	27,088	
Pyrene	1290000	27.000	14,000	5,600	14,000		< 105		27,000	0,594	10.592	
t – Methylnaphthalene	90120	J 890		J 430	58,000	1,100			58,000	29,144	24,804	
	91576	3,400		J 1,600	89,000	,						
2 – Methylinéphtheliene	1 1	' 1		' 1		3,600			89,000	35,030	38,606	
2 – Methylchrysené												
Naphthelene	3351324 91203	25,000 3,100		47,000 J 1,900	24,000 12,000	9,200		19,422 3,611	47,000 12,000	16,447	29,332 6,187	

OFF-SPEC PRODUCT and FINES from THERMAL PROCESS

Di-n-bulylphthelate
Benz (a) antihracene
Benzo(a)pyrene
Bit (2 - ethylhexyl) phthalate
Chrysene
2-Methylchrysene
1 - Methylnephthalene
2 - Methylnephihalene
Phenol

Aluminum Chromium Copper Iron Leed Merganese Mercury Nickel Selenium Vanedium Zinc

fron Lead Mercally Zinc

TOUR Danie alex						100 ·								1	20% Confidence	
TCLP Semivolat															nterval	
CAS No		R0-TP-01		R8A-TP-01		Att-TP-Dt	R12-TP-01		R14-TP-01		R38-TP-01	Average Conc	Maximum Conc	Std: Dev	Upper Limit	Commente
84742		14				20	J 50	<	50	<	50	41	50	15	50	
56553	<	50	<	50	J	13	< 50	<	50	<	50	13	13	NA	NA	1
50328	<	50	۱<	50	J	10	< 50	<	50	<	50	10	10	NA	NA	1
117817	<	50	ı	230	JΕ	49 .	J 20	<	50	<	50	75	230	77	121	•
218019	<	50	<	50	J	35		ŧ	50	~	i i	35	35	NA	NA	,
3351324	۱ <	100	<	100	L	15		•	100	Ł	1	15	15	NA	NA	•
90120	ے ا	100	۱,		ŧ	100		ŧ	100			21	21	NA	NA.	,
91676	1	50			•	50			50		- 1	23	23	NA.	1	
108952	ł							•	-		1				NA.	1
108923	₹18	17	۱<	60	۱ <	60	< 50	 <	50	<	50	17	17	NA	NA	1
									•						90% Confidence	
Total Metals - A	leth	ode 6010,700	Ю,	, 7421 , 7470, 7	47	l, and 7841 mg/	Neg								Interval	
CAS No		R6-TP-01		P8A-TP-01		A11-TP-01	R12-TP-01		A14-TP-01		R3B-TP-01	Average Conc	Maximum Conc	Std Dev	Upper Limit	Comments
7429006		84.0	1	17.0	<	90.0	130.0	<	20.0			50.8	130.0	45.6	84.3	
7440473	1 2	1.D	ے ا		_	10	3.0		4.0	۔ ا	• •					

CAB No. R6-TP-01 R8A-TP-01 R11-TP-01 R12-TP-01 R12-TP-01 R3B-TP-01 Average Conc Maximum Conc Std Dev Upper Limit Comments 7429905 84.0 1.0 < 1.0 < 1.0 3.0 < 20.0 < 20.0 < 20.0 56.8 130.0 45.8 84.3 7440473 < 1.0 < 1.0 < 1.0 3.0 < 1.0 < 1.0 1.3 3.0 0.8 1.8 7440608 < 2.5 < 2.5 < 2.5 13.0 5.1 < 2.5 4.7 13.0 4.2 7.2 7439808 230.0 190.0 50.0 600.0 370.0 < 100 275.0 600.0 288.0 448.5 7439021 2.5 0.8 < 0.3 1.1 3.7 < 0.3 1.5 3.7 1.4 2.3 7439025 < 1.5 < 1.5 < 1.5 7.0 < 1.5 < 1.5 < 1.5 2.4 7.0 2.2 3.8 7439076 < 0.05 < 0.05 < 0.05 0.05 0.0283 0.11 < 0.05 < 0.05 0.05 0.00 0.01 0.03 0.07
7440473 < 1.0 < 1.0 < 1.0 3.0 < 1.0 < 1.0 1.0 3.0 0.8 1.8 7440608 < 2.5 < 2.5 2.5 2.5 13.0 5.1 2.5 4.7 13.0 4.2 7.2 7430808 230.0 190.0 50.0 600.0 370.0 100 275.0 600.0 288.0 448.5 7430921 2.5 0.8 < 0.3 1.1 3.7 < 0.3 1.5 3.7 1.4 2.3 7430905 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 3.8 < 3.8
7440473 1.0 1.0 3.0 1.
7440608 2.5 2.5 2.5 13.0 5.1 2.5 4.7 13.0 4.2 7.2 7430808 230.0 190.0 50.0 600.0 370.0 100 275.0 600.0 268.0 448.5 7430921 2.5 0.8 0.3 1.1 3.7 0.3 1.5 3.7 1.4 2.3 7430905 1.5 1.5 7.0 1.5 2.4 7.0 2.2 3.8
7439921 2.5 0.8 < 0.3 1.1 3.7 < 0.3 1.5 3.7 1.4 2.3 7439905 < 1.5 < 1.5 < 1.5 7.0 < 1.5 < 1.5 < 1.5 2.4 7.0 2.2 3.8
7439985 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5 < 1.5
7439976 < 0.05 < 0.05 0.0283 0.014 0.05 0.05 0.05 0.01 0.01
7440020 46.0 12.0 34.0 16.0 120.0 8.5 39.3 120.0 42.1 54.6
7782492 < 0.5 < 0.5 1.4 0.5 0.5 0.7 1.4 0.4 0.9
7440622 61.0 70.0 110.0 76.0 310.0 28.0 109.5 310.0 101.7 170.8
7440868 7.8 7.5 6.6 20.0 13.0 20 9.5 20.0 6.2 13.2

		CLF Metats — Methods 1311, 6010, 7060, 7421, 7470, 7471, and 7641 mg/L										90% Confidence interval				
	CAS No.	_	Ra-TP-OI	R8A-TP-01		A11-TP-01	A12-TP-01		A14-TP-01		R3B-TP-Cf	Average Conc	Maximum Conc	Std Dev	Lipper Limit	Commente
1	7439898	<	0.50	< 0.50	<	0.50	1.40	<	0.50	<	0.50	0.65	1.40	0.37	0.87	
1	7439921	<	0.015	< 0.015	<	0.015	< 0.015		0.03	<	0.015	0.02	0.03	0.01	0.02	
1	7439976		0.000334	0.000378		0.000588	0.000398	<	0.005		0.000308	0.000401	0.000588	0.000111	0.000477	1
-	7440666		0.75	0.31		0.74	0.37		0.30	<	0.10	0.43	0.75	0.26	0.50	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Upper Limit exceeds the maximum concentration.

Notes:

- 8 Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass special data indicate the presence of a compound that meets the identification criteria for which the result is less than the isboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.

3.8 LIQUID TREATING

3.8.1 Process Description

Liquid treating processes, for the purposes of this investigation, are synonymous with caustic treating. The purpose of caustic treating is to remove sulfur compounds such as mercaptans, H₂S, and phenolic sulfur compounds. Caustic treating of FCC fractions also removes cresylic acids, while treating jet fuel derived from certain crudes (such as some Delta, Venezuelan, Russian crudes) also removes naphthenic acids. Liquid treating consists of the countercurrent flow of the untreated light distillate with a solution of 5 to 20 percent caustic. The caustic can be regenerated to a certain degree by steam stripping or air contacting. In addition to regeneration, make-up caustic is required to maintain the effectiveness of the system. Figure 3.8.1 provides a generic process flow diagram for H₂SO₄ alkylation. The industry also employs oxidative caustic treating, which converts mercaptans to disulfides (which remain in the treated product) (McKetta).

Untreated JP-4

Ist Stage

Ist Stage

Inhibitor

Inhibitor

Treated JP-4

Spent Caustic to Storage

Figure 3.8.1. Liquid Treating Process Flow Diagram

3.8.2 Spent Caustic - Residual 14

3.8.2.1 Description

A slip stream of spent caustic is continuously drawn off the caustic treater and replaced with fresh caustic to maintain caustic strength of 5 to 20 percent. The spent caustic is either sent offsite via tanker truck, railcar, or barge to Merichem for reclamation, discharged to the refinery's wastewater treatment system (sometimes for pH control), or reused in some way in the refinery's processes (e.g., FCC wet gas scrubbers, recovery of ammonia in sour water systems, makeup for desalter water, or reuse in a treating unit).

The spent caustic exhibits the RCRA characteristic for corrosivity. Currently, 54 facilities reported managing their spent caustic as hazardous, reporting primarily corrosivity, but also ignitability, reactivity and TC benzene. Over 64,000 MT of the caustic were reported as hazardous. This number may have been significantly higher except for the industry's practice to manage spent caustic sent to Merichem as a refinery by-product rather than a spent material. In addition, Merichem actively encourages refineries not to manifest their caustics destined for Merichem.

3.8.2.2 Generation and Management

The §3007 questionnaire responses indicated 917,656 MT of spent caustic were generated in 1992. Residuals were assigned to be "spent caustic from liquid treating" if they were assigned a residual identification code of "spent caustic, which corresponds to residual code 04-A in Section VII.2 of the questionnaire. Caustic from the HF alkylation process, and other residuals on a case-by-case basis, were eliminated from this assignment upon determination that the caustic was not used in a liquid treating operation. In this industry study, spent caustic is the second largest-volume waste being examined. Table 3.8.1 provides a description of the total quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.8.1. Generation Statistics for Spent Caustic from Liquid Treating								
Final Management	# of Streams	# with Unreported Volume	Total Volume (MT)	Average Volume (MT)	90th % Volume (MT)			
Storage in a tank	398	36	534,505.3	1,342.98	2,426			
Discharge to WWTP; discharge to surface waters; discharge to publically or privately owned treatment works	196	31	246,356.6	1,257	3,989			
Disposal in onsite or offsite underground injection well ²	20	1	11,731.1	586.56	952.5			
Disposal onsite surface impoundment	2	0	616.8	308.4	596			
Other discharge or disposal offsite	2	0	1,600	800	800			
Offsite incineration	1	0	144.6	144.6	144.6			
On-site industrial furnace	1	0	791	791	791			
Neutralization	24	1	21,631.5	901.31	1,184			
Transfer to another petroleum refinery	5	0	284.1	56.82	147			
Transfer to a paper mill	6	0	5,599.41	933.24	3,120			
Transfer of caustic for reclamation	200	8	450,684	2,253.42	4,649			
pH control	10	0	2,211.3	221.13	668.5			
Ammonia recovery	2	0	174.8	87.4	165.7			
Recycle in FCC wet gas scrubber	2	0	36,209	18,104.5	36,000			
Recovery in sulfur plant	2	O	40	20	20			
Reuse as desalter water	3	0	904.6	3 01. 5 3	560			
Recovery as pH buffer at WWTP	27	11	21,615.58	800.58	3,173			
Reuse onsite in a caustic treater	20	0	13,605.12	680.26	2,425			
Onsite caustic regeneration	17	5	96,929.5	5,701.74	30,000			
Other misc. recycling, recovery, reclamation	7	0	2,091.8	298.83	900			
Total spent caustic ¹	630	82	917,655.8	11,456.6	3,000			

¹ Additional miscellaneous non-final management practices were reported, accounting for less than 0.5 percent of the total residual volume. Totals do not add due to possible double counting of interim management steps (i.e., storage, then neutralization, then discharge to WWTP).

² Three facilities have onsite injection wells: 2 have Class I wells, 1 did not report in the §3007 survey. Seven facilities send waste to four offsite injection wells: 2 are Class I wells, 2 did not provide data in §3007 survey.

The RCRA §3007 questionnaire showed that the majority of spent caustic is stored in tanks prior to management at the wastewater treatment plant or at Merichem. Merichem uses the cresylic and naphthenic caustics as raw materials (and often purchases these caustics from the refineries) in specialty chemicals manufacturing processes. Their products include a wide range of cresylic and naphthenic acids. Merichem also uses sulfidic caustics as reagents in their processes, but does not typically pay the refineries for these caustics. In addition, Merichem serves as a caustic broker between refineries and paper mills who can use certain sulfidic caustics as a substitute for sodium hydroxide, sodium hydrosulfide, sodium sulfide, or sulfur.

The residual caustic value of the spent caustic is used at some refineries in units where pH control is useful, including desalters, sour water strippers, ammonia control, and wet scrubbers, as well as in the wastewater treatment facilities. A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.8.2.

Given the aqueous nature of the residual and typical management practices, the Agency determined that the risk assessment should model tank storage. Table 3.8.3 characterizes the tanks reported to manage spent caustics in the §3007 questionnaires. Table 3.8.4 provides the volume information used to perform the risk assessment.

The Agency performed a screening analysis to determine the effect of spent caustic on contaminant concentrations in aggressive biological treatment (ABT) sludges at petroleum refining facilities. The analysis was performed by:

- determining the volume of spent caustic discharged to onsite WWTPs,
- determining the average total volume of wastewater discharged to a wastewater treatment facility at a petroleum refinery,
- calculate the proportion of total wastewater volume that is represented by the spent caustic wastestream,
- establish which contaminants occur in wastewater treatment sludges from ABT, establishing which of these contaminants also occur in the spent caustic and focusing the evaluation on these contaminants, and
- apply the dilution factor calculated in Step 3 to the concentration of contaminants in wastewater treatment sludges from ABT to determine the concentration attributed to the spent caustic. (This step assumes that contaminant concentration in the non-spent caustic portion of the wastewater input are equivalent to the concentrations in the spent caustic wastestream.)

The volume of spent caustic discharged to onsite WWTPs was provided in responses to the §3007 survey. The concentration of contaminants detected in the spent caustic were

determined through EPA's sampling and analysis. The results of the analysis showed a spent caustic dilution factor of approximately 2.5 percent.

Table 3.8.2. Selection of Risk Assessment Modeling Scenario: Spent Caustic from Liquid Treating							
Waste	Basis for Consideration in Risk Assessment						
Storage in a tank	Modeled						
Discharge to WWTP; discharge to surface waters; discharge to POTW	Not modeled due to coverage of existing sludge listings, the exempt status of effluent discharges, the benzene NESHAPs, the						
Discharge to onsite WWTP	MACT standards for volatile emissions, and the proposed LDR Phase III and IV rulemakings.						
Discharge to onsite WWTP; ultimate NPDES discharge							
Offsite incineration	Not modeled, Subtitle C incineration						
Reuse onsite in a caustic treater	Not modeled, exempt management practice						
Transfer of caustic for reclamation	Not modeled, exempt management practice						
Discharge to offsite privately-owned wastewater treatment works	Not modeled, covered by existing regulations						
Disposal in onsite or offsite underground injection well	Not modeled, covered by existing regulations and LDR Phase III						
Disposal onsite surface impoundment	Not modeled, covered by existing regulations and LDR Phase III						
Onsite industrial furnace	Not modeled; relatively small volume only reported at one facility out of 630 streams; unlikely to cause emissions concerns						
Recycle in FCC wet gas scrubber	Not modeled, exempt management practice						
Recovery in sulfur plant	Not modeled, exempt management practice						
Reuse as desalter water	Not modeled, exempt management practice						
Recovery as pH buffer at WWTP	Not modeled, exempt due to use as an ingredient or reagent						
Transfer to a paper mill	substitute (261.2(e))						
Transfer to another petroleum refinery	Not modeled, exempt management practice						
Onsite caustic regeneration	Not modeled, exempt management practice						

The Agency considered whether there was a need to conduct a risk assessment of the wastewater treatment system, but determined that the combinations of the existing F and K sludge listings, the Benzene NESHAPs, and, because of the corrosive characteristic of this waste, the LDR Program's Phase III and Phase IV rulemakings would address any residual risk associated with spent caustics mixed with all other refinery wastewaters (and subsequently significantly diluted to less than 3% of original concentrations). Similarly, the Agency

determined that risks associated with underground injection would be adequately addressed by the Phase III rulemakings.

3.8.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.8.5 summarizes the physical properties of the tank sludge as reported in Section VII.A of the §3007 survey.
- Six record samples of spent caustics were collected and analyzed by EPA. These samples represent the three major types of spent caustics generated by the industry and are summarized in Table 3.8.6.

All the samples collected are believed to be representative of spent caustic as generated by the petroleum refining industry. Sulfidic caustics are the most commonly generated (as reported in the survey), followed by cresylic, and, in smallest quantities, naphthenic caustics. The sample profile reflects this distribution. Table 3.8.7 provides a summary of the characterization data collected under this sampling effort.

Table 3.8.3. Spent Caustic Tank Characterization								
Parameters	# Reporting "Yes"	# Reporting "No"						
Tank Covered?	15	140						
Secondary Containment?	108	47						
Volume Statistics (MT):		150 5 381,821 ,722,810 8,400 42,150 860,000						

Table 3.8.4. Management Practices Targeted for Risk Assessment							
Spent Caustics from Liquid Treating							
Parameters	# of RC	# RC w/ Unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)	
Storage in Tank	***	398	36	534,505		172.15	2,426

Table 3.8.5. Spent Caustic Physical Properties						
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %	
рН	392	316	10	11.92	14	
Reactive CN, ppm	70	637	0	24.27	110	
Reactive S, ppm	111	596	5	11,546	24,000	
Flash Point, °C	105	602	0	245.3	98.9	
Oil and Grease, vol%	126	581	0	1.93	5	
Total Organic Carbon, vol%	97	610	0	7.6	22	
Vapor Pressure, mm Hg	64	643	0.1	13*	50	
Viscosity, lb/ft-sec	48	659	0	1.48	10	
Specific Gravity	322	386	1.02	1.16	1.3	
BTU Content, BTU/lb	62	645	0	747.6	1,000	
BOD, mg/L	52	655	0	12,553	25,000	
COD, mg/L	54	653	0	47,993	200,000	
Aqueous Liquid, %	513	195	90	94.36	100	
Organic Liquid, %	370	338	0	4.13	5	
Solid, %	369	339	0	2.29	1.5	

^{*} Used the 50th percentile because the arithmetic mean was higher than the 90th percentile due to an erroneous data point.

Ta	Table 3.8.6. Spent Caustic Record Sampling Locations								
Sample Number	Facility	Description							
R3-LT-01	Exxon, Billings, MT	Tank sampled, concentrated cresylic caustic							
R3-LT-02	Exxon, Billings, MT	Tank sampled, concentrated sulfidic caustic							
R6-LT-01	Shell, Norco, LA	Naphthenic caustic from treating gas oil and kero							
R13-LT-01	Shell, Deer Park, TX	Sulfidic caustic							
R12-LT-01	Texaco, Anacortes, WA	Cresylic caustic							
R22B-LT-01	Star, Port Arthur, TX	Sulfidic caustic from H ₂ SO ₄ alkylation							

3.8.2.4 Source Reduction

The primary purpose of liquid treating is the removal of sulfur compounds. The industry has several established technological options that generate significantly less residual than liquid treating (but require significant capital expenditure). Hydrotreating technologies remove sulfur compounds and generate residuals (spent catalyst) only upon unit turnaround every 2 to 5 years. Oxidative caustic treating

Industry sources indicate that the Agency's investigation of spent caustics for potential listing has influenced some corporations to commit resources to replacing their traditional caustic treating units with hydrotreating and oxidative caustic treating to minimize their potential hazardous waste management burden.

generates much smaller amounts of spent caustic because the sulfur compounds are converted to disulfide oils, which remain in the treated hydrocarbon stream rather than accumulating in the caustic.

Merichem and the paper industry provide recovery opportunities for spent caustics, allowing for the recovery of the cresylic and naphthenic acids and the sulfur content of the spent caustics.

Table 3.8.7. Spent Caustic Characterization

		90% Confidence Volatile Organics - Method \$269A μα/i.										
	CAS No.	POSMINE Urganics			040 IT 04	040 17 01	Doop IT of				interval	
44	CAS NO. 67641	15.000			A13-LT-DI					Standard Deviation	Upper Limit	Comments
Acetone		,		5,000	39),000	6,700 J	50	69,542	390,000	157,085	164,197	
Benzene	71432			5,000		2,200		652	2,200	888	1,261	1
Carbon disulf de	75150	1 1	1,400 <	5,000		< 500 <		540	1,400	510	894	1
Ethylbenzene	100414	J 710 <	1	11,000	540	530		2,272	11,000	4,284	4,853	_
n-Propylbenzene	103651	J 560 <		5,000		< 500 <		215	360	233	723	5
Toluene	108883	J 740 J	[21,000	920	4,000 <		4,485	21,000	8,219	0,437	
1,2,4—Trimethylbenzene	95636	8,500 <	f	51,000	2,200			10,534	51,000	20,067	22,626	
1,3,5 - Trimethylbenzene	108878	1,500 <		20,000		< 500		3,896	20,000	7,905	8,682	
o-Xylene	95478	2,500 <		21,000	1,500			4,423	21,000	8,165	0,043	
m,p-Xylenes	108383 / 106423	4,000 J		49,000	3,000	2,400		9,776	49,000	19,278	21,394	
Mathyl ethyl letone	78933	6,500	570	11,000	1,400	2,300 <		3,653	11,000	4,291	6,239	
Naphthalene	91203	2,900		29,000	7,800	1,900 <		7,025	29,000	11,118	13,724	
4 - Methyl - 2 - pentanone	108101	< 500 <		5,000	780	1		468	780	262	846	1
Styrene	100425	< 500 <	500 <	, 5,000	3,300	< 500 -	50	₽7 6	1,300	1,317	1,873	ş
											90% Confidence	
		Samivolatile Organ	nice Mathod 8	2708 uul							interval	
	CAS No.	A3-LT-01		R6-LT-Ot	R13-LT-01	A12-LT-01	R22B-LT-01	Average Conc	Maximum Conc	Standard Deviation		Comments
2,4 - Dimethylphenot	105679	2,570,000 J		340,000 [1,000		2,570,000	973,988	1,202,871	
Indene	95136	< 50,000 <		1,250			-		5,600	2,904	5.645	1
kophorone	78591	< 50,000 <		1,250	16,000	< 6,250	400	5,975	10,000	7,164	11,643	•
2 - Methylphenol	95467	32,400,000	229,000	99,000	150,000	1,900,000	6,600		32,400,000	13,052,152	13,662,327	-
3/4 - Mathylphenol	NA .	54,600,000	610,000	170,000	77.000	5,500,000	9,100		54,600,000	21,862,678	23,330,293	
Phenol	108952	92,500,000	1,600,000	24,000		E 22,000,000	8,500	19,372,933	92,600,000	35,903,814	41,510,230	
Benzenethiol	108985	1,130,000	6,070,000 <	2,500				1,434,550	6,070,000	2,355,174	2,853,718	
1 - Methylnaphthalene	90120	< 100,000 <			< 3,425		- 1	10,606	33,000	15,038	22,923	1
2 - Methyinaphihalene	91576				< 1,713	, ,		7,203	22,000	10.027	15,416	1
Naphthalene	91203	,		26,000	15,000				25,000	11,845	22,101	1
respiration to	1	10,000		20,220,	,,-	-,,				.,		
											90% Canfidence	
	ł .	lathods 6010, 706									Interval	
	CAS No.	#3+LT-01		R6-LT-01	R13-LT-01					Standard Deviation	Upper Limit	Comments
Ara enic	7440382	26.00	5.00 <	0.10			2.40	5.62	26.00	10.17	11.75	
Chromium	7440473			0.005	1	0.015	0.015	300.0	0.015	0.005	0.011	
Cabalt	7440484	< 0.25			< 0.25	23.00 <		4.04	23.00 0.087	9.29 0.030	9.64 0.043	
Capper	7440508	< 0.013		0.013		1	0.087	0.025				
kan	7439996	< 0.05		0.05		24.00	1.20	4.23	24.00	0.50	10.08	
tead	7439921	0.27	0.12 <	0.03	- 1	1		0.09	0.27	0.10	0.14	
Manganese	7439985	< 0.008		0.008			0.016		0.018	0.003	0.011	
Hercury	7439076	0.270		0.005		0.270		6.093	0.270	0.137	0.176	
Potassium	7440097			2.50		< 2.50	300.00	52.08	300.00	121,45	125.27	
Se lenium	7782492	0.35	0.68 <	0.03				0.11	0.35	0.12	0.18	
Sodium	7440235	110,000	43,000	12,000	34,600	54,000	89,000	59,333	110,000	15,866	80,944	
T hei tium	7440290			0.05		0.38		0.11	0.38	0.13	0.10	
Zine	7440666	< 0.01	0.01	0.44	< 0.01	< 0.01	0.08	0.00	3.44	0.17	0.20	

SPENT CAUSTIC from LIQUID TREATING

	Miscellaneous Characterization	90% Conlidence
ignitability (of) Corrosivity (pH units) Reactivity ~ Total ReleasebleH2S (mg/L)	R3-LT-01 R3-LT-02 R6-LT-01 R13-LT-01 R12-LT-01 R22B-LT-01 Average Conc Maximum Conc Standard Deviation > 210	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- Upper Limit exceeds the maximum concentration.

Nates:

- B. Analyte also detected in the associated method blank.
- J Compound's concertration is estimated. Mass special data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection and, but greater than zero.
- E Concentration exceeds the upper calibration standard.
- ND Not Detected.
- NA Not Applicable.

3.9 H₂S REMOVAL AND SULFUR COMPLEX

3.9.1 Process Description

All crude oil contains sulfur, which must be removed at various points of the refining process. The predominant technique for treating light petroleum gases is (1) amine scrubbing followed by (2) recovery of elemental sulfur in a Claus unit followed by (3) final sulfur removal in a tail gas unit. This dominance is shown in Table 3.9.1, which presents the sulfur complex/removal processes reported in the RCRA §3007 questionnaire.

Table 3.9.1. Sulfur Removal Technologies Reported in RCRA §3007 Questionnaire						
Technique	Number of Facilities	Percentage of Facilities ¹				
Amine-based sulfur removal	106	86				
Claus sulfur recovery ²	101	82				
Other sulfur removal or recovery	16	13				
SCOT®-type tail gas unit	50³	41				
Other tail gas treating unit	19³	15				

¹ Percentage of the 123 facilities reporting any sulfur removal/complex technique.

Caustic or water is often used in conjunction with, or instead of, amine solution to remove sulfur, particularly for liquid petroleum fractions. These processes, however, are generally not considered sulfur removal processes because either (1) the sulfur is not further complexed from these solutions (i.e., is not removed from the solution), or (2) if removed, it occurs in a sour water stripper which is in the domain of the facility's wastewater treatment system. Such processes are considered to be liquid treating with caustic, which is discussed in Section 3.8.

3.9.1.1 Amine Scrubbing

A typical process flow diagram for an amine scrubbing system is shown in Figure 3.9.1. The purpose of the unit is to remove H₂S from refinery fuel gas for economical downstream recovery. Fuel gas from the refinery is fed to a countercurrent absorber with a 25 to 30 percent aqueous solution of amine such as monoethanolamine (MEA), diethanolamine (DEA), or methyldiethanolamine (MDEA). The H₂S reacts with the amine solution to form a complex, "rich" amine. Typically, a refinery will have several absorbers

² Note that more facilities perform sulfur removal than perform sulfur recovery. Some refineries ship their H₂S-containing amine offsite to another nearby refinery.

³ Only 47 facilities were coded to have SCOT^o-like units in the database, but closer examination revealed that 3 additional facilities with "other systems" really had SCOT^o-like units.

located throughout the refinery depending on the location of service. These "rich" streams are combined and sent to a common location at the sulfur plant where the H₂S is stripped from the amine in the reverse reaction. The "lean" amine is recycled back to the absorbers.

Lean Amine to other units in the refinery HaS to Claus Unit Sweetened Cas Water Wash Sour Fuel Cas Skimmed from PCC Heat Stable Salt Sludge een Amine Rich Amine Skimme Stip Stream Rich Amine from other units in the refinery

Figure 3.9.1. Simplified Flow Diagram of the Amine Sulfur Removal Process

3.9.1.2 Claus Unit

The H₂S from the sulfur removal unit is most often recovered in a Claus system as elemental sulfur. A typical process flow diagram for a Claus unit is shown in Figure 3.9.2. In a Claus unit, the H₂S is partially combusted with air to form a mixture of SO₂ and H₂S. It then passes through a reactor containing activated alumina catalyst to form sulfur by the following endothermic reaction:

$$2 H_2S + SO_2 --> 3 S + 2 H_2O$$

The reaction is typically conducted at atmospheric pressure. The resulting sulfur is condensed to its molten state, drained to a storage pit, and reheated. The typical Claus unit consists of three such reactor/condenser/reheaters to achieve an overall sulfur removal yield of 90 to 95 percent. At this point the tail gas can be (1) combusted and released to the atmosphere, or (2) sent to a tail gas unit to achieve greater sulfur reduction.

Furnace Reactor Catalyst

Spent Catalyst

Sulfur Condenser Gas Unit

Product Sulfur to Sales

Figure 3.9.2. Simplified Flow Diagram of the Claus Sulfur Recovery Process

3.9.1.3 SCOT® Tailgas Unit

The most common type of tail gas unit is the Shell Claus Offgas Treating (SCOT®) unit. A typical process flow diagram for a SCOT® unit is shown in Figure 3.9.3. Its purpose is to recover and recycle sulfur, in the form of H₂S, to the Claus unit. Tail gas (containing H₂S and SO₂) is contacted with H₂ and reduced in a hydrotreating reactor to form H₂S and H₂O. The catalyst is typically cobalt/molybdenum on alumina. The gas is then cooled in a water contactor. The water circulates in the column and requires periodic purging due to impurity buildup; filters may be used to control levels of particulates or impurities in the circulating water.

The H_2S containing gas enters an amine absorber which is typically in a system segregated from the other refinery amine systems discussed above. The purpose of this is two-fold: (1) the tail gas frequently uses a different amine than the rest of the plant, such as MDEA or diisopropyl amine (DIPA), and (2) the tail gas is frequently cleaner than the refinery fuel gas (in regard to contaminants) and segregation of the systems reduces maintenance requirements for the SCOT® unit. Amines chosen for use in the tail gas system tend to be more selective for H_2S and are not affected by the high levels of CO_2 in the offgas.

The "rich" amine generated from this step is desorbed in a stripper; the lean amine is recirculated while the liberated H₂S is sent to the Claus unit. Particulate filters are sometimes used to remove contaminants from lean amine.

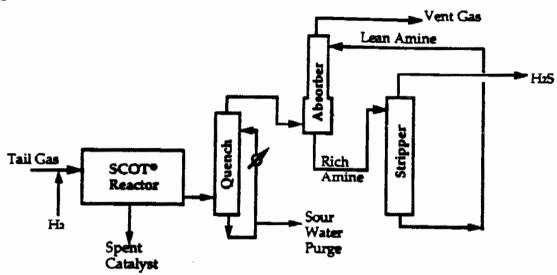


Figure 3.9.3. Simplified Flow Diagram of the SCOT® Tail Gas Sulfur Removal Process

3.9.1.4 Other Processes

Although the amine/Claus/SCOT® train described above is the dominant system used in the industry, it is not exclusive. Some refineries, mostly small asphalt plants, do not require sulfur removal processes at all, while others use alternative technologies. In order of usage, the alternative processes are as follows:

Sulfur Removal/Recovery Processes

- Sodium hydrosulfide. Fuel gas containing H₂S is contacted with sodium hydroxide in an absorption column. The resulting liquid is product sodium hydrosulfide (NaHS).
- Iron chelate. Fuel gas containing H₂S is contacted with iron chelate catalyst dissolved in solution. H₂S is converted to elemental sulfur, which is recovered.
- Stretford. Similar to iron chelate, except Stretford solution is used instead of iron chelate solution.
- Ammonium thiosulfate. In this process, H₂S is contacted with air to form SO₂. The SO₂ is contacted with ammonia in a series of absorption column to produce ammonium thiosulfate for offsite sale. (Kirk-Othmer, 1983)
- Hyperion. Fuel gas is contacted over a solid catalyst to form elemental sulfur.
 The sulfur is collected and sold. The catalyst is comprised of iron and naphthoquinonsulfonic acid.

- Sulfatreat. The Sulfatreat material is a black granular solid powder; the H₂S forms a chemical bond with the solid. When the bed reaches capacity, the Sulfatreat solids are removed and replaced with fresh material. The sulfur is not recovered.
- A few facilities report sour water stripping, which is not part of the scope of the survey and is likely to cause severe underestimates of the actual number of sour water strippers in existence.
- Hysulf. This process is under development by Marathon Oil Company. Hydrogen sulfide is contacted with a liquid quinone in an organic solvent such as n-methyl-2-pyrolidone (NMP), forming sulfur. The sulfur is removed and the quinone reacted to its original state, producing hydrogen gas (The National Environmental Journal, March/April 1995).

Tail Gas Processes

- Beavon Stretford tail gas. A hydrotreating reactor converts SO₂ in the offgas
 to H₂S. The H₂S is contacted with Stretford solution (a mixture of vanadium
 salt, anthraquinone disulfonic acid, sodium carbonate, and sodium hydroxide),
 where it reacts to form elemental sulfur. The elemental sulfur is recovered
 and sold.
- Caustic scrubbing. An incinerator converts trace sulfur compounds in the offgas to SO₂. The gas is contacted with caustic which is sent to the wastewater treatment system.
- Polyethylene glycol. Offgas from the Claus unit is contacted with this solution to generate an elemental sulfur product. Unlike the Beavon Stretford process, no hydrogenation reactor is used to convert SO₂ to H₂S. (Kirk-Othmer, 1983)
- Selectox. A hydrogenation reactor converts SO₂ in the offgas to H₂S. A solid catalyst in a fixed bed reactor converts the H₂S to elemental sulfur. The elemental sulfur is recovered and sold. (Hydrocarbon Processing, April 1994).
- Sulfite/Bisulfite Tail Gas Treating Unit. Following Claus reactors, an incinerator converts trace sulfur compounds to SO₂. The gas is contacted with sulfite solution in an absorber, where SO₂ reacts with the sulfite to produce a bisulfite solution. The gas is then emitted to the stack. The bisulfite is regenerated and liberated SO₂ is sent to the Claus units for recovery. (Kirk-Othmer, 1983)

3.9.2 Sludge from Sulfur Complex and H2S Removal Facilities - Residual 15

3.9.2.1 Description

Impurities such as carbon dioxide can irreversibly react with the amine (forming heat stable salts) and interfere with system operation; rust particles can also form in the system. Heat stable salts also can contribute to corrosion by degrading to organic acids, and aiding in the formation of ferrous sulfide. Ferrous sulfide can also contribute to foaming in hydrocarbon/amine separators, resulting in the loss of amine in the hydrocarbon.

For this reason, particulate or heat stable salt removal systems are common on the system's "lean" side. Control methods depend on the type of amine in use, the quality of the fuel gas being treated, economics, etc., and include particulate filters, activated carbon, diatomaceous earth, regeneration (reboiling), and caustic addition. All of these control methods, except caustic addition, generate residuals periodically (weekly to biannually), which are included in the scope of sulfur sludge. Filters and activated carbon require periodic replacement when spent; many facilities backwash the particulates from these filters to the sewer system to prolong the service life of the filters. In a regenerator, the amine/water is boiled off to leave a sludge containing heat stable salts and other corrosion products. Filters and activated carbon can be used for any system, while only low-boiling amine solutions such as MEA are effectively controlled with a reboiler.

Sludge from the sulfur complex includes all sludges, filters, adsorbents, and other media used in a sulfur removal system. Based on the above process descriptions in Section 3.9, the following processes potentially generate sludge:

- Amine-based sulfur removal (106 facilities)
- Stretford-based sulfur removal (2 facilities)
- Other miscellaneous sulfur removal processes (14 facilities)
- SCOT®-like tail gas treatment (50 facilities)
- Beavon-Stretford tail gas treatment (14 facilities)
- Other miscellaneous tail gas treatment processes (5 facilities).

Sludges or wastes from Claus units are generally limited to those generated during turnaround/maintenance activities. Such wastes were generally classified as waste sulfur, a study residual, and were not part of the scope of sulfur sludge. In addition, amine that is discharged from the system is specifically excluded from the scope of "sulfur sludge." Instead, this residual is considered in the scope of off-spec treating solution from sulfur recovery, which is a study residual.

1992 Identification of Sulfur Sludge

D007 (TC Chromium) 2,336 MT D010 (TC Selenium) 1,216 MT D003 (Reactive) 1,209 MT

Total identified as hazardous: 2,446 MT (the most common codes are listed; some streams carry multiple codes)

Approximately 2,446 MT of sulfur sludge generated in 1992 were identified as displaying hazardous characteristics. This is approximately 29 percent of the total quantity managed.

3.9.2.2 Generation and Management

As discussed in Section 3.9.1, the amine sulfur removal process is the dominant sulfur removal process for gas streams used in the industry. The next most frequently used process is the Stretford sulfur removal/complex process. Sludges generated from the Stretford process will not be addressed by EPA in its decision-making because it is a small and distinct segment of the industry's sulfur removal capability. The remaining sulfur sludges are generated from the remaining types of processes discussed in Section 3.9.1.

Only sludges from the amine system were considered in the listing determination. Sludges from other processes, including the Stretford process, are specifically excluded because they are generated by far fewer facilities in much smaller quantities than the amine process sludges. Only 2 facilities reported generating sludge from the Stretford process compared to 103 facilities generating sludge from the non-Stretford process.

Based on observations made during engineering site visits, interim management of the sludges sent to wastewater treatment includes contained vacuum trucks or discharge to the facility sewer system. All other interim management is conducted in open or closed drums or dumpsters.

Ninety-four facilities reported generating a total quantity of 8,520 MT of this residual in 1992, according to the 1992 RCRA §3007 Questionnaire. Residuals were assigned to be "sulfur sludge" if they were assigned a residual identification code of "other process sludge" or "spent sorbent" and were generated from a sulfur complex or H₂S removal process. These correspond to residual codes 02-D and 07, respectively, in Section VII.2 of the questionnaire and process code 15 in Section IV-1.C of the questionnaire. Sludges from the Stretford process were segregated on the basis of the generating unit: sludges originating from Stretford systems or Beavon-Stretford tail gas systems (corresponding to process codes 15-B and 15-E, respectively), in Section IV-1.C of the questionnaire were included in this category. Based on the results of the questionnaire, approximately 106 facilities use amine in their refinery sulfur removal system or their tail gas sulfur removal system. The remaining facilities likely do not generate sludges from their amine sulfur removal systems because they can control corrosion and particulates using methods other than ion/solids removal; caustic addition is an example of such a method.

Table 3.9.2 provides a description of the quantity generated, number of streams reported, number of unreported volumes, and average and 90th percentile volumes.

Table 3.9.2. Generation	Statistics f	or Non-Stretfo	ord Sulfur	Table 3.9.2. Generation Statistics for Non-Stretford Sulfur Sludge, 1992										
Final Management	# of Streams	# with unreported volume	Total Volume (MT)	Average Volume (MT)	90th % Volume (MT)									
Disposal offsite Subtitle D landfill	95	15	4,041	43	70									
Discharge to wastewater treatment	33	6	3,442	104	100*									
Onsite incineration ²	3	1	197	66	192									
Disposal in onsite Subtitle D landfill	18	0	195	11	53									
Disposal offsite in Subtitle C landfill	54	9	149	3	3									
Offsite carbon regeneration	15	0	104	7	27									
Onsite land treatment	8	1	73	9	50									
Offsite land treatment	3	0	34	11	18									
Disposal in onsite Subtitle C landfill	13	1	29	2	4									
Offsite incineration	9	2	8	1	4									
Miscellaneous ⁱ	15	0	247	16	88									
TOTAL	266	35	8,520	32	40									

^{*} Estimate

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the "high potential exposure" disposal practices currently used, which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.9.2 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practices are:

 Offsite Subtitle D landfilling (used for 47 percent of the total quantity of generated sludge). This scenario was chosen because it is used for a significant volume of waste and is expected to be a high potential exposure management method. An onsite monofill scenario was rejected because of the low quantity of residual generated at individual facilities.

¹ Miscellaneous management includes: recycle to the process, offsite recycling, reuse (not specified if onsite or offsite), regeneration (not specified if onsite or offsite), steam stripping, onsite recovery in coker, transfer to make a fuel, and offsite cleaning of reusable filter disc.

² Two facilities: one with a Part B permit and the other uses a trash burner (refractory-lined pit) to burn refuse and non-hazardous process waste,

- Onsite Subtitle D landfilling (used for 2.3 percent of the total quantity of generated sludge). This scenario was chosen because it is expected to be a high potential exposure management method. An onsite monofill scenario was rejected because of the low quantity of residual generated at individual facilities.
- Onsite land treatment (used for 1 percent of the total quantity of generated sludge). This scenario was chosen because it was demonstrated to be in use and could be used by other facilities.
- Interim onsite storage. This scenario was chosen because all sludges could potentially be stored onsite in open containers prior to further management. The Agency observed during engineering site visits and sampling trips that sludge from sulfur complex operations is generated on a regular basis (e.g., weekly) and the Agency observed facilities that maintain storage areas on the process units for dumpsters used to accumulate filter cartridges. This practice also poses the potential for ongoing air emissions and was modeled in EPA's risk assessment.

The sludges managed in wastewater treatment systems were not chosen for evaluation in the risk assessment because these sludges will settle out in the primary treatment steps and are already listed as hazardous. A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.9.3.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.9.4 provides a summary of the data for the targeted management practices used in the risk assessment for the sulfur sludges.

3.9.2.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.9.5 summarizes the physical properties of the tank sludge as reported in Section VII.A of the §3007 survey.
- Five record samples of actual sludges were collected and analyzed by EPA.

 These samples represent the various types of sludges generated by the industry and are summarized in Table 3.9.6.

Table 3.9.3. Selection of Risk Assessment Modeling Scenario: Non-Stretford Sulfur Sludge								
Final Management	Basis for Consideration in Risk Assessment							
Disposal offsite Subtitle D landfill	Modeled							
Discharge to wastewater treatment	Not modeled. Sludge would settle out in and be captured by existing hazardous waste listings. Wastewater discharge is exempt. Air pathways controlled by Benzene NESHAPs. Impact on WWTP expected to be minimal due to small volume of waste in relation to the total volume of wastewater typically treated. Sediments would be further controlled by the Phase IV LDR standards when the sediments exhibit any of the characteristics.							
Onsite incineration	Not modeled. Majority of waste is burned in Subtitle C permitted unit, no incremental risk to model. Balance of volume is much less than 100 mt.							
Disposal in onsite Subtitle D landfill	Modeled							
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control							
Offsite carbon regeneration	Not modeled, exempt management							
Onsite land treatment	Modeled							
Offsite land treatment	Modeled							
Disposal in onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control							
Offsite incineration	Not modeled, <i>de minimis</i> volume							
Miscellaneous ¹	Not modeled, exempt management practices							

¹ Miscellaneous management includes: recycle to the process, offsite recycling, reuse (not specified if onsite or offsite), regeneration (not specified if onsite or offsite), steam stripping, onsite recovery in coker, transfer to make a fuel, and offsite cleaning of reusable filter disc.

Table 3.9	.4. Man	agement	Practices T	argeted fo	or Risk As	sessment	·
Parameters	# of Fac.	# of RC	# RC w/ unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Dumpster Storage		152	6	4,156		0.77	27
Onsite and Offsite	50	113	15	4,236		4	69.3
Subtitle D Landfill ^{3,4}			Onsite I	andfill Char	acteristics	·	,
	Surface A	rea (acres)			0.46	7,7	36
	Remaining	g capacity	(thousand cu.yd.)		3.7	66.7	6,500
	Percent re	maining ca	pacity		0.7	9.5	80
	Total caps	city (thous	and cu.yd.)		7.3	112.9	8,000
	Number o	f strata in	completed unit		0	1	400
	Depth bel	ow grade (ft)		0	7	23
	Height ab	ove grade	(ft)		0	6	35
	# of Land	fills: 16					
			Ac	uifer Inform	ıtion		
	Depth to	Aquifer (ft)			8.5	20	166
	Distance t	o Private \	Well (ft)		2,500	6,200	26,400
	Population	Using Pri	vate Well		1	1.5	2
	Distance t	o Public V	\eII (V)		7,000	15,840	58,000
	Population	u Using Pu	blic Well		1,500	1,750	2,000
	# of Aqui	fers: 15					
	Source: Public Private						
	Current o	r potential dered a po	permost Aquifer: source of drinkin tential source of d	-	r (12)		

Table 3.9	.4. Mana	igement	Practices T	argeted fo	r Risk As	sessment			
Parameters	# of Fac.	# of RC	# RC w/ unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)		
Offsite Land Treatment Unit ^{2,3}	3	3	0	34	a.u	10	18.2		
Onsite Land Treatment	6	8	1	73		2.25	50		
Unit ^{1,3}				Characteristic	:5				
	Surface A	rea (acres)			4	16	105		
	Depth of I	ncorporati	on (in)		6	10	12		
	Amount A	pplied (19	92 MT)²		2	152	10,190		
	Methods o	Methods of Incorporation: Disking 8 Subsurface Injection 1 Bulldozing 1							
	# of Land	Treatment	Units: 10						
			Ac	uifer Informa	tion				
	Depth to A	Aquifer (ft)			15	21	97		
	Distance to	Private V	Vell (ft)		2,000	5 ,500	25,000		
	Population	Using Pri	vate Well		O	0	1		
	Distance to	o Public W	/ell (ft)		15,000	15,000	15,000		
	Population	Using Pu	blic Well		10,000	10,000	10,000		
	# of Aquit	iers: 9							
	Source: Public Private								
	Current or	potential dered a pot	permost Aquifer: source of drinkin tential source of o		: (5)				

¹ The number of onsite land treatment units characterized in Table 3.9.4 is greater than indicated in Table 3.9.2 which focuses only on volumes generated in 1992. Table 3.9.4 incorporates data from all onsite land treatment units receiving sludge in any year reported in the §3007 survey.

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² Volumes represent the average volume of all wastes applied to the land treatment units accepting the non-Stretford sulfur sludge and not just the sulfur sludge alone.

³ The 50th and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

⁴ Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

Table 3.9.5. S	ulfur S	ludge Physical	Propertie	s	
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %
pН	183	235	4.5	7.9	10
Reactive CN, ppm	102	315	0	29	50
Reactive S, ppm	134	283	0.05	1,347	500
Flash Point, C	110	304	60	84	102
Oil and Grease, vol%	66	349	0	2.1	7.5
Total Organic Carbon, vol%	56	361	0	12.8	63.9
Viscosity, Ib/ft-sec	3	414	0	0.02	0.07
Specific Gravity	77	341	0.24	1.5	1.52
BTU Content, BTU/lb	35	382	1,900	8,000	12,700
Aqueous Liquid, %	251	167	0	17.6	75
Organic Liquid, %	222	196	0	3.1	7.5
Solid, %	322	96	25	84.3	100
Particle > 60 mm, %	101	317	0	78	100
Particle 1-60 mm, %	86	332	0	29	100
Particle 100 μm-1 mm, %	75	343	0	8.1	30
Particle 10-100 μm, %	73	345	0	7.3	2
Particle <10 μm, %	70	348	0	0.5	0
Mean Particle diameter, microns	20	389	0	480	1,500

Table 3.9.6. Sulfur Sludge Record Sampling Locations								
Sample number	Facility	Description: Amine and sludge type						
R1-ME-01	Marathon Indianapolis, IN	MEA, reclaimer bottoms						
R5-ME-02	Marathon, Garyville, LA	MDEA, filter cartridges						
R6-ME-01	Shell, Norco, LA	DEA, filter cartridges						
R14-ME-01	BP, Toledo, OH	DEA, diatomaceous earth						
R18-ME-01	Ashland, Canton, OH	MEA, reclaimer bottoms						

All of the samples were taken from refinery amine systems and are believed to represent all sludges, sorbents, and filter media generated from amine systems. No samples from the tail gas system units were collected. These residuals are expected to be cleaner because the feeds are cleaner. Therefore, the tail gas treating residuals are expected to exhibit levels of contaminants no higher than those found in the sampled residuals.

Of the sludges characterized, all represent the physical or chemical removal of particulates from a slip stream of amine treating solution. Activated carbon is a frequently used sorption medium which was not sampled; the sampling results of other wastes are expected to represent this residual because similar contaminants are being removed. In addition, none of the sampled residuals were taken from the tail gas treating section.

An effective cross-section of the treating solutions used in refineries was represented in the sampling. The RCRA §3007 Questionnaire did not specifically request information on the type of amine solution used, but based on information supplied by some refineries and from engineering site visits, the solutions MEA and DEA are frequently used to treat refinery fuel gas while MDEA is used less frequently for this purpose. MDEA is frequently used in the SCOT® tail gas unit. Disopropanol amine (DIPA) is also used for treating.

As discussed in Section 3.9.1, systems other than amine are used to remove sulfur from refinery fuel gas or tail gas. These include, but are not limited to, the Stretford process. These residuals were not represented by the sampling. As stated before, this listing determination focuses on the sludges from the amine treating process because it is the most widely used system.

All six samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. All samples were also analyzed for corrosivity, reactivity, ignitability, and total amines. None of the TCLP extracts of the analyzed samples exhibited levels of constituents in excess of their regulatory levels. One sample exhibited the characteristic of corrosivity, while two samples exhibited levels of releasable H₂S in excess of 1,000 mg/kg. The two MEA reclaimer samples higher levels of iron can be attributed to a higher amount of concentrated corrosion products (rust and scale) in the sludge. A summary of the results is

presented in Table 3.9.7. Only constituents detected in at least one sample are shown in this table.

3.9.2.4 Source Reduction

There are many opportunities to reduce the toxicity or volume of this residual. The primary reason sludges are generated is to remove impurities from the amine system to maintain satisfactory operation. Two immediate methods to reducing sludge volume are: (1) using a different amine that is less sensitive to the impurities, and (2) using different methods to control or remove these impurities that would generate less waste.

As an example of the first method, many refineries use methyl diethanolamine (MDEA) instead of monoethanolamine (MEA) at the tail gas unit. MDEA is not as susceptible to the formation of heat stable salts and is amenable to regeneration. Using MDEA greatly reduces the amount of amine sludge generated by the tail gas unit.

Examples to the second method include the following:

- At least two facilities control heat stable salts in their MDEA amine treating
 system using a proprietary caustic. With heat stable salt generation being
 controlled, the refineries do not have to use their cloth filters as much and thus
 can reduce the frequency of generation. Other facilities have mentioned the
 use of corrosion inhibitors to serve the same purpose.
- Cloth cartridge filters are a common particulate control technique in the amine system. At least two facilities have replaced their cloth or cartridge filters with an etched metal mechanical filter. The new filter requires less maintenance, reduces or eliminates the number of filter elements disposed of, and also conserves the quantity of amine in the system, as amine is no longer lost during the filter change-out procedure.
- At least one facility using treating clay replaced this material with regenerative carbon. The carbon can be regenerated onsite while the clay, presumably, could not be.

Table 3.9.7. Residual Characterization Data for Sulfur Sludge

	Votelile Organicu	- Method 8260A	uałka							90% Confidence Interval	
	CAS No.	R1-ME-01	R5-ME-02	RO-ME-01	R14-ME-01	R18-ME-01	Average Conc	Maximum Conc	Sld Dev	Upper Limit	Comments
Acetone	87041	6,800	< 25	< 1,250	< 525	J 670	1,834	6,500	2,699	1,665	COMMINGING
Benzene	71432	< 2,500	90	< 1,250	< 625	J 420	258	420	229	757	1. 2
n-Butylbenzene	104516	7,200	< 25	J 700	< 825	< 600	1,830	7,200	9,014	3,896	* -
Carbon disuside	75160	< 2,500	150	< 1,260	< 625	< 600	150	150	NA	NA	1
Ethylbenzene	100414	9,600	210	J 1,100	< 525	< 600	2,427	9,600	4,022	5,185	
4-Methyl-2-pentanone	108101	78,000	< 25	< 1,250	< 625	< 500	16,100	78,000	34,606	39,825	
Methylana chiorida	75092	< 2,500	< 25	< 1,250	< 625	J 150	88	150	88	260	1, 2
n-Propylbenzene	103651	6,600	< 25	< 1,250	< 625	< 600	1,820	6,600	2,707	3,676	
Toluene	108883	13,000	410	J 510	< 625	< 600	3,029	13,000	5,575	0,851	
1,2,4-Trimettyibenzene	95538	47,000	240	J 1,800	J 500	< 600	10,048	47,000	20,685	24,216	
1,3,5Trimethylbanzene	108678	18,000	340	J 520	< 625	< 600	3,817	16,000	6,023	8,383	
o-Xylene	95478	16,00)	210	< 1,250	< 525	< 600	3,737	15,000	6,685	3,444	
m,p-Xylenes	106383 / 108423	54,000	570	J 1,000			11,392	54,000	23,819	27,722	
Naphthelene	\$1203	34,000	< 25	2,500	j 920	J 240	7,537	34,000	14,825	17,701	
				. =						90% Confidence	
	CAS No.	penics – Method R1–ME-Di	1311 and 6260A		DAA ME O	D44 MF -4	A	14 4 0		interval	_
Acotona	67641		R5-ME-02	R6-ME-01				Maximum Conc	Std Dev	Upper Limit	Comments
Acatone Bengane	71432	8 160 < 50	< 50 < 50	< 50 < 50	< 50 < 50	B 150 J 26	96 26	180	64 HA	140	_
Ethythenzene	100414	130	< 50	< 50	< 50		20 56	26 130		NA	1
Methylane chibrida	75092	c 50	< 50	< 50		≺ 50 JB 24	96 24	130	30 NA	01	
Toluene	108883	500	< 60	· 50	· 50	عد ح 50	140	500	201	NA 276	*
1,2,4~Trimethylbenzene	95636	210	< 50	j 23	₹ 50	< 50	77	210	75	128	
O-Kviene	95476	260	< 50	< 50	₹ 50	· 50	92	260	15	156	
m,p-Xylene	198383 / 196423	630	< 50	< 50		< 50	160	630	250	344	
Naphthalene	91203	1	< 50	J 49				49	25	85	1,2
•		• •	•						1		
	Semiyoleille Orga	mios — Mothod S	OTOR valva							90% Contidence Interval	
	CAS No.	Rs-ME-01	P5-ME-02	R6-ME-01	R14-ME-01	A18-ME-01	Austron Cono	Maximum Conc	StdDev	Upper Limit	Comments
Acenephthene	63329		< 3,300	< 16.500	< 2.063	< 165	3,332	7,500	3,248	5,990 tsmit	COMMENTS
Anthracene	120127		< 3,300	< 16,500	980	< 185	2,301	5,000	2,204	4,100	,
Chrysene		< 6,500	< 3,300	< 18,500	1 2,600	< 165	1,383	2,600	1,722	5,130	1,2
Dibenzoluren	132549	< 6,600	< 3,300	< 16,500		< 105	1,033	1,900	1,227	3,703	1, 2
Flugrane	66737	J 6,700	< 3,300	< 16,500	6,500	< 105	5,186	8,700	4, 197	8,579	`.
trophorone	78591	J 6.700	< 3,300	< 10,500	< 2,063	500	3,166	6,700	2,602	5,297	•
2-Methylchayeere	3351324	< 13,200	< 6,500	< 33,000	J 1,400	< 330	885	1,400	757	2,512	1.2
1-Methylnephthelene	90120	39,000	37,000	< 33,000	19,000	< 330	25,666	39,000	16, 174	36,755	
2-Methylnaphthatene	P1576	58,000	87,000	< 18,500	29,000	530	38,208	87,000	34,453	61,828	
Nephthalena	91203	J \$3,000	18,000	< 18,500	< 2,063	< 165	9,045	18,000	6,201	15,630	
Phenanthane	85018	27,000	< 3,300	< 16,500	14,000	560	12,278	27,000	10,635	19,588	
Pyrene	129000	J 6,500	< 3,300	< 10,500	J 4,000	< 165	3,491	5,500	2,508	5,628 ;	1
										0% Confidence	
			thods 1311 and 6							Interval	
	CAS No.	R1-ME-01	R5-ME-02	R6-NE-01	R14-ME-01	R18-ME-01	Average Conc	Maximum Conc	Sld Dev	Upper Limit	Comments
Benzo(a)pyrene	50328		< 50	< 50	< 50	< 50	15	18	HA	NA	1
Bis (2-ethythexyl) phihalate	117817		< 50	J 96	< 50	< 50	56	96	23	82	
Di-n-butyl phthalete	84742	< 50	JB 18	JB 12	< 50	J 74	40	74	26	58	
1 - Methylnaphthalene	90120	J 78	J 32	< 100		1 18	39	76	25	60	1
2-Methylnaphthelene	91576	J 94	J 68	< 50		J 17	54	94	29	73	
3/4-Methylphensi (lotal)	1 510 1	1									
b) - b M- d	NA CAROO	< 50	< 50	< 50	J 50	< 50	53	56	7	58	
Naphthalana	91203	J 63	J 42	< 50	< 50	< 50	57	93	20	71	
Naphthelene Phenanthene Phenol	1						57 12		- 1		1

SULFUR COMPLEX SLUDGE

	1											
										1	90% Contidence	
	Total Metals - N										Interval	
Aluminum	CAS No. 7429905	R1 ME 01 230.0	R5-ME-02 340.0			R14-ME-01	H18-ME-0		Maximum Conc	Std Dev	Upper Limit	Communits
Arthory	7440360	< 0.0	< 6.0	1	20.0 14.0		3,000. 35.	1	3,600.0	1,527.1	1,022.0	
Asserio	7440382	33.0	< 1.0	1	17.0		35. 120.		35.0 120.0	12.6 49.7	22.0	
Cadmium	7440439	1.1	< 0.5	•	9.5		3.	1		1.2	68.4 2.0	
Calcium	7440702	7,700.0	< 600.0	•	500.0	7,500.0	14,000.			5,892,8	0.042.0	
Chromium	7440473	270.0	18.0	ŧ	18.0	23.0	900.	1	900.0	381.4	507.3	
Cobalt	7440484	11.0	39.0	ŧ	5.0	_	24.		39.0	14.0	26.8	
Соррег	7440508	87.0	94.0	1	81.0	78.0	150.	98.0	150.0	29.7	116.4	
Train .	7439898	170,000.0	76,000.0		28,000.0	34,000.0	220,000.	105,600.0	220,000.0	85,528.8	184,235.2	
1_ead	7439921	< 0.3	0.0	<	0.3	0.6	2.	1.0	2.7	1.0	1.7	
Magnesium	7439954	2,300.0	< 500.0	<	500.0 ◄	590.0	< 500.	850.0	2,300.0	695.0	1,411.9	
Mangenes s	7439965	1,800.0	180.0		270.0	160.0	1,500.	646.0	1,600.0	871.7	1,443.0	
Molybelenum	7439987	16.0	13.0	<	6.5	0.5	64.	21.8	64,0	24.2	38.4	
Nickel	7440020	80.0	240.0		60.0	19.0	750,		750.0	305.3	435.1	
Setentum	7782492	140.D	1,3		9.5		1,200.			523.1	628.9	
Sodium	7440235	61,000.0	< 500.0		500.0		26,00 0.			22,612.5	31,202.6	
Vanadum	7440622	36.0	20.0		5.0		-			\$4.0	24.6	
Znc	7440668	39.0	10.0	l	35.0	14.0	68.) 37.2	88.0	31.1	58.5	
	1											
	1										000 D 01	
	TCI P Mateix I	lathoda 1211 AN	IO 7080 7/21 7	7.47n	747) and 784	t med					90% Confidence	
	TCLP Metals - L						RiaMFo	Average Cons	Maximum Cone		interrel	Commonto
Arsenic	CAS No.	R1-ME-01	R6-ME-02		RO-ME-01	R14-ME-01	R18ME0		Maximum Cone	StdDev	interrel Upper Limit	Comments
Arsenic Berlum	CAS No. 7440382	R1-ME-01 < 0.05	R6-ME-02 < 0.05		R0-ME-01 0.49 <	R14-ME-01 0.05	< 0.0	0.14	0.40	Std Dev 0.20	Intervel Upper Limit 0:27	Comments
Arsenic Barlum Celcium	CAS No.	R1-ME-01 < 0.05	R6-ME-02		R0-ME-01 0.49 < 2.70 <	R14-ME-01 0.05		0_14 0 1.34	0.49 2.70	Std Dev 0.20 0.75	Interval Upper Limit 0.27 1.86	Comments
Barlum	CAS No. 7440362 7440393	R1-ME-01 < 0.05 < 1.00	R6-ME-02 < 0.05 < 1.00		R0-ME-01 0.49 <	R14-ME-01 0.05 1.00 160.00	< 0.0 < \$_0	0.14 1.34 132.20	0.49 2.70	Std Dev 0.20	Intervel Upper Limit 0:27	Comments
Barlum Cekclum	CAS No. 7440362 7440393 7440439	R1-ME-01 < 0.05 < 1.00 51.00	R6-ME-02 < 0.05 < 1.00 < 25.00		R0-ME-01 0.49 2.70 25.00	R14~ME~01 0.05 1.00 160.00 0.05	< 0.0 < 1.0 400.0 0.1	0.14 1.34 1.32.20 0.08	0.49 2.70 400.60	Std Dev 0.20 0.75 159.74	Intervel Upper Limit 0.27 1.86 241.71	Comments
Barlum Calcium Chromium	CAS No. 7440382 7440383 7440439 7440479	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05		R0-ME-01 0.49 < 2.70 < 25.00 0.12 <	R14-ME-01 0.05 1.00 160.00 0.05	< 0.0 < \$.0 400.0 0.1 < 0.2	0.14 1.34 1.32.20 0.08 0.38	0.49 2.70 400.60 0.12 0.91	Std Dev 0.20 0.76 159.74 0.04	Intervel Upper Limit 0:27 1.86 241.71 0.10	Comments
Barium Calcium Chromium Cobalt	CAS No. 7440362 7440393 7440439 7440473 7440484	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.05 < 0.25	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01		R0-ME-01 0.49 < 2.70 < 25.00 0.12 < 0.25 <	R14-ME-01 0.05 1.00 160.00 0.05	< 0.0 < \$.0 400.0 0.1 < 0.2	0 1.34 1.34 1.32.20 0.08 0.38	0.49 2.70 400.60 0.12 0.91	Std Dev 0.20 0.76 159.74 0.04 0.30	Intervel Upper Limit 0.27 1.86 241.71 0.10 0.86	Comments
Bartum Calcium Chromium Cobalt Copper	CAS No. 7440382 7440393 7440439 7440473 7440484 7440506 7439890 7439991	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.81 < 0.13		R0-ME-01 0.49 < 2.70 < 25.00 0.12 < 0.25 < 0.41 <	R14-ME-01 0.05 1.00 180.00 0.05 0.25 0.13 250.00	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.1 280.0 < 0.0	5 0.14 1.34 1.32.20 0.08 5 0.36 0.18 2.28.00 2 0.25	0.49 2.70 400.60 0.12 0.01 0.41 570.00	Std Dev 0.20 0.76 159.74 0.04 0.30 0.13	Intervel Upper Limit 0:27 1:86 241.71 0.10 0.56 0.27	Comments
Bartum Calcium Cobalt Copper Iron Lead Menganese	CAS No. 7440362 7440362 7440439 7440473 7440484 7440566 7439666 743965 743965 743966	R1-ME-01 < 0.05 < 1.00 < 51.00 < 0.05 < 0.25 < 0.13 280.00 < 0.02 380.00	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.81 < 0.13 130.00 0.11 5.10	A A	R8-ME-01 0.49 2.70 25.00 0.12 6.25 0.41 570.00	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02	< 0.0 400.0 400.0 0.1 4 0.2 4 0.2 4 0.0 280.0 4 0.0	0.14 1.34 1.32.20 0.08 0.38 0.038 0.048 0.298.00 2.025 13.42	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 183.00	Intervel Upper Limit 0:27 1.86 241.71 0.10 0.56 0.27 409.75	Comments
Bartum Celcium Chornium Cobalt Copper Iron Lead Manganese Nickel	CAS No. 7440362 7440363 7440439 7440464 7440506 7439666 7439666 7439666 7440600 7439666 7440020	R1-ME-01 < 0.05 < 1.00 < 0.05 < 0.05 < 0.25 < 0.13 280.00 < 0.02 < 0.02 < 0.02	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90	A A	R8-ME-01 0.49 < 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 <	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02 2.00 0.20	< 0.0 400.0 400.0 0.1 < 0.2 < 0.3 280.0 < 0.0 13.0	0.14 1.34 132.20 0.08 0.38 0.38 0.298.00 0.25 13.42 2.00	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.90	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 163.00 0.48 13.37 2.38	Interval Upper Limit 0.27 1.86 241.71 0.10 0.86 0.27 409.75 0.56 22.59 3.83	Comments
Bartum Celcium Chomium Chomium Coppar Iron Lead Manganese Nickel Selenkum	CAS No. 7440362 7440363 7440439 7440464 7440506 7439660 7439621 7439620 7782462 7782462	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13 260.00 < 0.02 < 0.02 < 0.02	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90 < 0.03	ж	R0-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 670.00 1.10 1.00 2.50 0.03	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02 2.00 0.03	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.3 280.0 < 0.0 13.0 1.2	0.14 1.34 1.32,20 0.06 0.38 0.18 0.298,00 0.25 13,42 0.20 0.04	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.00	Std Dev 0.20 0.76 159.74 0.34 0.13 183.00 0.48 13.37 2.38	Intervel Upper Limit 0.27 1.86 241.71 0.10 0.56 0.27 409.75 0.58 22.59 3.83 0.07	Comments
Bartum Celcium Chornium Cobalt Copper Iron Lead Manganese Nickel	CAS No. 7440362 7440363 7440439 7440464 7440506 7439666 7439666 7439666 7440600 7439666 7440020	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13 260.00 < 0.02 < 0.02 < 0.02	R6-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90	ж	R8-ME-01 0.49 < 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 <	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02 2.00 0.03	< 0.0 400.0 400.0 0.1 < 0.2 < 0.3 280.0 < 0.0 13.0	0.14 1.34 1.32,20 0.06 0.38 0.18 0.298,00 0.25 13,42 0.20 0.04	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.00	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 163.00 0.48 13.37 2.38	Interval Upper Limit 0.27 1.86 241.71 0.10 0.86 0.27 409.75 0.56 22.59 3.83	Comments
Bartum Celcium Chomium Chomium Coppar Iron Lead Manganese Nickel Selenkum	CAS No. 7440362 7440363 7440439 7440464 7440506 7439660 7439621 7439620 7782462 7782462	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13 260.00 < 0.02 < 0.02 < 0.02	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90 < 0.03	ж	R0-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 670.00 1.10 1.00 2.50 0.03	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02 2.00 0.03	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.3 280.0 < 0.0 13.0 1.2	0.14 1.34 1.32,20 0.06 0.38 0.18 0.298,00 0.25 13,42 0.20 0.04	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.00	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 163.00 0.48 13.37 2.38 0.04 1.00	Intervel Upper Limit	Comments
Bartum Celcium Chomium Chomium Coppar Iron Lead Manganese Nickel Selenkum	CAS No. 7440362 7440363 7440439 7440473 7440473 7440506 7439690 7439690 7439690 7439690 7440606	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.23 < 0.02 30.00 < 0.02 < 0.03 < 0.00 < 0.00	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90 < 0.03	ж	R0-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 670.00 1.10 1.00 2.50 0.03	R14-ME-01 0.05 1.00 160.00 0.05 0.25 0.13 250.00 0.02 2.00 0.03	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.3 280.0 < 0.0 13.0 1.2	0.14 1.34 1.32,20 0.06 0.38 0.18 0.298,00 0.25 13,42 0.20 0.04	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.00	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 163.00 0.48 13.37 2.38 0.04 1.00	Interval Upper Limit 0.27 1.86 241.71 0.10 0.56 0.27 409.75 0.56 22.59 3.63 0.07 1.69	Comments
Bartum Celcium Chomium Chomium Coppar Iron Lead Manganese Nickel Selenkum	CAS No. 7440363 7440393 7440439 7440473 7440464 7440506 7439660 7439660 7439660 7440606 Miscellansous C	R1-ME-01 < 0.05 < 1.00 < 0.05 < 0.25 < 0.13 260.00 < 0.02 < 0.02 < 0.00 < 0.00 < 0.00 < 0.00	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.81 < 0.13 130.00 0.11 5.10 5.90 < 0.03	Y Y	R0-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40 4	R14-ME-01 0.05 1.00 160.00 0.05 0.05 0.05 0.05 0.05 0.05 0.05	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.1 280.0 < 13.0 1.2 0.1 0.8	0.14 1.34 132.20 0.06 0.38 0.18 0.28 0.25 13.42 2.00 2.00 1.00 1.00	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.90 0.12 2.40	Std Dev 0.20 0.76 159.74 0.04 0.30 0.13 183.00 0.46 13.37 2.35 0.04 1.00	Interval Upper Limit	
Bartum Calcium Cobalt Copper Iron Lead Menganese Nickel Selenkum Zino	CAS No. 7440362 7440363 7440439 7440473 7440473 7440506 7439690 7439690 7439690 7439690 7440606	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13 260.00 < 0.02 < 0.02 < 0.03 < 0.00 < 0.4 0.00	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 130.00 0.11 5.00 < 0.03 1.60	Y Y Y	R8-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40	R14-ME-01 0.05 1.00 160.00 0.05 0.05 0.13 250.00 0.02 0.02 0.03	< 0.0 < 1.0 400.0 6.1 < 0.2 < 0.1 280.0 < 0.0 13.0 1.2 0.1 0.8	0 1.14 1.34 132.20 0.08 0.38 0.18 228.00 0.2 0.25 13.42 2.00 0.04	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.90 0.12 2.40	Std Dev 0.20 0.75 159,74 0.04 0.30 0.13 163,00 0.48 13,37 2.35 0.04 1.00	Interval Upper Limit	Comments
Bartum Calcium Chornium Cobalt Copper Iron Lead Manganese Nickel Selenkum Zinc Corrosivity (pH units)	CAS No. 7440363 7440393 7440439 7440473 7440464 7440506 7439660 7439660 7439660 7440606 Miscellansous C	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.28 < 0.02 < 0.02 < 0.02 < 0.03 < 0.10 maracterization R1-ME-01 13.3	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 < 0.13 130.00 0.11 5.10 5.90 < 0.03 1.60		R8-ME-01 0.49 2.70 0.50 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40 6	R14-ME-01 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1	< 0.0 < 1.0 400.0 0.1 < 0.2 < 0.1 280.0 < 0.0 13.0 1.2 0.1 0.8	0.14 1.34 132.20 0.08 0.38 0.18 208.00 0.25 13.42 2.00 0.04 1.00	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 36.00 5.90 0.12 2.40	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 163.00 0.48 13.37 2.36 0.04 1.00	Interval Upper Limit	
Bertum Calcium Chromium Cobalt Copper Iron Lead Manganese Nickel Selenium Zinc Corrostvity (pH units) Reactivity — Total ReleasebleH28 (mg/kg)	CAS No. 77440363 77440439 77440439 77440439 77440484 7743690 77439690 7743965 77439020 7782492 77440666 Miscellameous C CAS No.	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.23 < 0.02 < 0.02 < 0.00 < 0.00 < 0.00 < 10.00 Arracterization R1-ME-01 15.3	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 130.00 0.11 5.10 5.90 < 0.03 1.60 R5-ME-02 3.6		R8-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40 40 R8-ME-01 9.5	R14-ME-01 0.05 1.00 150.00 0.05 0.25 0.13 250.00 0.02 2.00 0.02 0.03 0.10 R14-ME-01 9.9	< 0.0 < 1.0 < 400.0 6.1 < 0.2 < 0.1 280.0 < 0.0 13.0 1.2 0.1 0.8 R18-ME-0 11. 6,10	0.14 1.34 132.20 0.06 0.38 0.18 208.00 0.25 13.42 2.00 2.0.04 1.00	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 38.00 5.90 0.12 2.40	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 183.00 0.46 13.37 2.38 0.04 1.00 Std Dev	Interval Upper Limit	
Bartum Calcium Chornium Cobalt Copper Iron Lead Manganese Nickel Selenkm Zino CorrosMly (pH units) Rescrivity — Total ReleasableH2S (mg/kg) Amines — Moncethanolamina (mg/kg)	CAS No. 7440363 7440393 7440439 7440439 7440484 7440500 7439921 7439921 7439925 7440020 7782492 7440606 Miscellansous C CAS No.	R1-ME-01 < 0.05 < 1.00	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05	A A A A	R8-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40 R8-ME-01 9.5 25 5 5	R14-ME-01 1.00 180.00 100.05 0.05 0.13 250.00 0.02 0.02 0.03 0.03 0.10 R14-ME-01 9.9	< 0.0 < 1.0 400.0 6.1 < 0.2 < 0.1 280.0 < 0.0 13.0 1.2 0.1 6.10 < 8.10 < 0.0	0.14 1.34 132.20 0.08 0.38 0.18 228.00 0.25 13.42 2.00 0.04 1.00	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 36.00 5.90 0.12 2.40 Maximum Conc NA 8,100 38,000	Std Dev 0.20 0.75 159,74 0.04 0.30 0.13 163,00 0.48 13,37 2.36 0.04 1,00 Std Dev NA 3,577 16,996	Interval Upper Limit	
Barium Calcium Calcium Cobalt Copper Iron Lead Manganese Nickel Selenkum Zinc Corrosivity (pH units) Rescrivity — Total ReleasebleH28 (mg/kg)	CAS No. 77440363 77440439 77440439 77440439 77440484 7743690 77439690 7743965 77439020 7782492 77440666 Miscellameous C CAS No.	R1-ME-01 < 0.05 < 1.00 51.00 < 0.05 < 0.25 < 0.13 280.00 < 0.02 < 0.03 < 0.10 maracterization R1-ME-01 13.3 < 28 38,000 < 500	R5-ME-02 < 0.05 < 1.00 < 25.00 < 0.05 0.01 130.00 0.11 5.10 5.90 < 0.03 1.60 R5-ME-02 3.6	* * * * * * * * * * * * * * * * * * *	R8-ME-01 0.49 2.70 25.00 0.12 0.25 0.41 570.00 1.10 11.00 2.50 0.03 2.40 40 R8-ME-01 9.5	R14-ME-01 1.00 180.00 100.05 0.05 0.13 250.00 0.02 0.02 0.03 0.03 0.10 R14-ME-01 9.9	< 0.0 < 1.0 400.0 6.1 < 0.2 < 0.1 280.0 < 0.0 13.0 1.2 0.1 0.8 R18-ME-0 11. 6,10 < 0.0	0.14 1.34 132.20 0.08 0.38 0.18 298.00 0.25 13.42 2.00 0.04 1.00 Average Conc NA 1,707 9,503 1,351	0.49 2.70 400.00 0.12 0.91 0.41 570.00 1.10 36.00 5.90 0.12 2.40 Maximum Cone NA 6,100 38,000	Std Dev 0.20 0.75 159.74 0.04 0.30 0.13 183.00 0.46 13.37 2.38 0.04 1.00 Std Dev	Interval Upper Limit	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations
- 2 Upper Limit exceeds the maximum concentration.

Notes:

- B Analyte also detected in the associated mathod blank.
- J Compound's concentration is estimated. Mass specified data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit but greater than zero.
- ND Not Delected.
- NA Not Applicable.

3.9.3 Catalyst from Sulfur Complex and H₂S Removal Facilities (Claus Catalyst) Residual 16

3.9.3.1 Description

Claus catalyst is a subset of the larger category of "catalyst from the sulfur complex and H₂S removal facilities." Sulfur catalyst includes all solid sulfur conversion catalyst used in a sulfur removal, recovery or tail gas unit. Liquid catalysts, such as Stretford solution, are not included in this scope but will instead be considered with treating solution from sulfur removal and complex operations, a study residual. Based on the above process descriptions, the following processes use solid catalysts:

- Alumina catalyst from Claus systems (86 facilities)
- Hydrotreating catalyst from SCOT[®]-like units (50 facilities)
- Hydrotreating catalyst from Beavon-Stretford tail gas treating units (14 facilities).
- Hyperion catalyst (1 facility)
- Other tail gas catalyst (1 facility).

Only alumina catalyst from Claus systems is included in the scope of this listing determination. Hydroprocessing catalyst from SCOT[®]-like, Beavon-Stretford, and Selectox systems is comprised of a combination of nickel and cobalt or molybdenum on alumina and is discussed in Section 3.3.4 with other hydroprocessing catalysts. The remaining two catalysts are unique to single facilities and because they are used at single facilities, they will not be considered further in this document.

The Claus catalyst requires periodic replacement due to losses in activity. It is generated during turnaround, approximately every 1 to 3 years. Typically, the entire volume of catalyst is removed and placed in containers for off-site management; fresh catalyst is then loaded into the unit.

1992 Identification of Claus Catalyst

D001 (Ignitable) 68 MT Managed as haz. 20 MT D002 (Corrosive) 6 MT

Total identified as hazardous: 94 MT

Approximately 94 MT of Claus catalyst generated in 1992 were identified as displaying hazardous characteristics. This is approximately 2 percent of the total quantity managed.

3.9.3.2 Generation and Management

Based on observations during engineering site visits and sampling events, interim management of the catalyst is conducted in roll-off bins or closed containers. Sixty-six facilities reported generating a total quantity of 3,819 MT of this residual in 1992, according to the 1992 RCRA §3007 Questionnaire. Residuals were assigned to be "Claus catalyst" if they were assigned a residual identification code of "spent solid catalyst" or "solid catalyst fines" and were generated from a process identified as a Claus unit. These correspond to residual codes 03-A and 03-B, respectively, in Section VII.2 of the questionnaire and process code 15-C in Section IV-1.C of the questionnaire. Catalyst from other units, such as tail gas units and miscellaneous sulfur recovery units discussed in Section 3.9.3.1, are excluded. Quality assurance was conducted by ensuring that all Claus catalysts previously identified in the questionnaire (i.e., in Section V.B) were assigned in Section VII.2. Based on the results of the questionnaire, approximately 101 facilities have Claus reactors. Due to the infrequent generation of this residual, not all facilities with Claus units generated spent catalyst in 1992. However, 1992 is expected to be a typical year in regard to spent catalyst volume and management. Table 3.9.8 provides a description of the quantity generated, number of streams reported, number of zero volumes, and average and 90th percentile volumes.

Table 3.	Table 3.9.8. Generation Statistics for Claus Catalyst, 1992										
Final Management	# of Streams	# with unreported volume	Total Volume (MT)	Average Volume (MT)	90th % Volume (MT)						
Disposal in offsite Subtitle D landfill	49	1	2,270	46	112						
Cement plant	14	0	722	52	170						
Disposal in onsite Subtitle D landfill	12	0	407.5	34	60						
Disposal offsite in Subtitle C landfill	8	1	256.5	32	107						
Offsite metal reclamation	6	0	133	22	59						
Disposal in onsite Subtitle C landfill	1	0	12	12	12						
Offsite land treatment	1	0	10.3	10.3	10.3						
Offsite incineration	1	0	5.8	5.8	5.8						
Reuse onsite catalyst support	1	0	1.9	1.9	1.9						
TOTAL	93	2	3,819	41	104						

Plausible management scenarios were chosen by EPA on which to perform the risk assessment model. The scenarios were chosen based on the numerous "high potential exposure" disposal practices currently used which negated the need for projecting hypothetical "plausible" mismanagement. Given the Agency's past experience with risk assessment modeling, the management practices summarized in Table 3.9.8 were reviewed to identify those practices likely to pose the greatest threats to human health and the environment. The selected management practice is:

- Onsite Subtitle D landfilling (11 percent of the volume of this residual was managed using this method). An onsite monofill scenario was rejected because of the intermittent generation frequency, which is not typical of waste that tends to be monofilled.
- Offsite Subtitle D landfilling (59 percent of the volume of this residual was managed using this method). Risks from disposal in an offsite Subtitle D landfill were assessed because it was the predominant method used in 1992.

A summary of EPA's reasoning in selecting pathways for quantitative risk assessment modeling is presented in Table 3.9.9.

The characterization data for the management units and their underlying aquifers were collected in the §3007 survey. Table 3.9.10 provides a summary of the data for the targeted management practices used in the risk assessment for the Claus catalyst.

Table 3.9.9. Selection of R	Table 3.9.9. Selection of Risk Assessment Scenario: Claus Catalyst								
Final Management	Basis for Consideration in Risk Assessment								
Disposal in offsite Subtitle D landfill	Modeled								
Cement plant	Not modeled, assumed small percentage of feed to cement kiln with very low levels of constituents of concern. Cement would tend to immobilize any trace metals present.								
Disposal in onsite Subtitle D landfill	Modeled								
Disposal offsite in Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control								
Offsite metal reclamation	Not modeled, see discussion of reclamation practices in Section 3.3.2								
Disposal in onsite Subtitle C landfill	Not modeled, already managed as hazardous - no incremental risk to control								
Offsite land treatment	Not modeled, very rare practice, small volume unlikely to cause risk								
Offsite incineration	Not modeled, very rare practice, small volume unlikely to cause risk								
Reuse onsite catalyst support	Not modeled, de minimis volumes, exempt management practice								

Table 3.9.	10. Man	agemen	t Practices T	argeted fo	or Risk As	ssessment	
Parameters	# of Fac.	# of RC	# RC w/ unreported Volume	Total Volume (MT)	10th % Volume (MT)	50th % Volume (MT)	90th % Volume (MT)
Onsite and Offsite	37	61	1	2,677	Montes	30	220
Subtitle D Landfill ^{1,2,3}			Onsite L	andfill Char	acteristics		
	Surface A	trea (acre	s)		0.1	7	36
	Remainin	g capacity	(thousand cu.y	/d.)	0.7	38	838
	Percent r	emaining	capacity		0.7	9	80
	Total cap	acity (tho	usand cu.yd.)		2.0	83.7	840
	Number	of strata i	n completed uni	t	1	10	208
	Depth be	low grade	(ft)		3	12	25
	Height al	ove grade	e (ft)		3	12	40
	# of Land	ifills: 17					
			Aqı	uifer Inform	ation		
	Depth to	Aquifer (ft)		6	16	166
	Distance	to Private	Well (ft)		1,000	5,280	26,400
	Populatio	n Using I	Private Well		1	2	10
	Distance	to Public	Well (ft)		5,000	14,525	58,000
	Populatio	n Using I	Public Well		1,500	2,000	2,000
	# of Aqu	ifers: 17					
	Source: Public Private Unreported 12 11 Uppermost 2 3 Lowermost 3 1 Combination 2						
	Current o	r potentia	ppermost Aquif al source of drin otential source	king water (

¹ The number of onsite landfills characterized in Table 3.9.10 is greater than indicated in Table 3.9.8 which focuses only on volumes generated in 1992. Table 3.9.10 incorporates data from all onsite landfills receiving catalyst in any year reported in the §3007 survey.

² The mean and 90th percentile were determined by using a management unit loading method (i.e., more than one waste stream may be disposed of in one management unit causing the 90th percentile number to actually be the sum of 2 or 3 waste volumes).

Models used the same input volumes for both on- and offsite Subtitle D landfill scenarios.

3.9.3.3 Characterization

Two sources of residual characterization were developed during the industry study:

- Table 3.9.11 summarizes the physical properties of the spent Claus catalyst reported in Section VII.A of the §3007 survey.
- Three record samples of actual spent Claus catalysts were collected and analyzed by EPA. These catalysts represent three facilities using the same process and are summarized in Table 3.9.12.

Table 3.9.11.	Spent Cl	aus Catalyst Pl	hysical Pro	perties	
Properties	# of RC	# of Unreported Values	10th %	Mean	90th %
рН	92	112	3.8	5.7	10
Reactive CN, ppm	59	145	0	14.3	10
Reactive S, ppm	70	134	0.01	23.5	100
Flash Point, C	57	147	54.4	95	160
Oil and Grease, vol%	24	177	0	0.3	1.0
Total Organic Carbon, vol%	24	179	0	1.0	2.5
Specific Gravity	73	131	0.75	2.5	3.2
BTU Content, BTU/lb	9	195	0	773	3,000
Aqueous Liquid, %	98	106	. 0	0.6	2
Organic Liquid, %	88	116	0	1.3	1
Solid, %	160	44	98	99.3	100
Particle > 60 mm, %	40	164	0	22	100
Particle 1-60 mm, %	72	132	50	84	100
Particle 100 μm-1 mm, %	57	147	0	6	50
Particle 10-100 μm, %	31	173	0	3	0
Particle < 10 μm, %	31	173	0	0.3	0
Mean Particle diameter, microns	17	182	0	4,700	13,000

The collected samples are expected to be representative of the spent Claus unit catalyst as generated. There are essentially no process variations with the Claus process. All units

use alumina catalyst and all treat a purified stream of H₂S. Contaminant levels in this catalyst, therefore, are not expected to exhibit significant variation across the industry.

Table 3.9.12.	Claus Sulfur Recovery Cataly	st Record Sampling Locations
Sample number	Facility	Description: Catalyst Type
R1-\$C-01	Marathon, Indianapolis IN	Alumina
R4-SC-01	Little America, Evansville WY	Alumina
R5-SC-01	Marathon, Garyville LA	Alumina

As discussed in Section 3.9.1, the four sulfur recovery processes in the industry using solid catalyst are the Claus, SCOT[®], Selectox, and the Hyperion process. SCOT[®] catalyst is discussed in Section 3.3.4. The Hyperion and Selectox catalysts are not expected to be represented by this sampling and are not considered in this listing determination.

All three samples were analyzed for total and TCLP levels of volatiles, semivolatiles, and metals. Samples were also analyzed for ignitability. None of the analyzed samples exhibited any hazardous waste characteristic. The high concentration of aluminum can be attributed to the alumina make up of the catalyst. A summary of the results is presented in Table 3.9.13. Only constituents detected in at least one sample are shown in this table.

3.9.3.4 Source Reduction

Like other catalysts, little can be done to reduce the quantity of this generated catalyst since, by design, it must be periodically replaced with fresh catalyst. The greatest pollution prevention opportunity is to prolong the life of the catalyst by improving the quality of the incoming H_2S .

Table 3.9.13. Residual Characterization Data for Spent Claus Unit Catalyst

	Volatije Organice	- Method 826	oA µq/ka					,	90% Confidence	
	CASNe.	B1-8C-0		-01	R5-SC-01	Averses Conc	Maximum Conc	Std Dev	Caper Limit	Comments
Acatone	67041	2.50	,	100 <	r	873	2.500	1.400	2.408	
Acetonialle	75358	< 82	- ;	21		21	21	1,74	22	1.2
Tolungs	108183	< 82	-1		180	23	180	124	352	1.2
1,2,4 — Trimuliyibenzane	93838	2,60	- I	5 <		975	7.600	1,494	2.502	1,2
	78633		-1	-;	1		1.400	-,		
Melhyl elhyl kelone		1,40	- į	38	1	488		792	1,348	
Nephindere	91203	\$7,000	01<	5 <	< 20	6,875	17,000	800,0	10,354	
	TCLP Volatile Or								90%, Confidence Interval	
	CAS No.	R1 - SC-0	_ , .		PS-SC-OI		Maximum Conc	Std Dev	Upper Llank	Comments
Acetore	67M1	84	0 < `	50 4		313	840	456	610	
Acelonitie	75058	< 5	9	100 <	c 50	67	100	29	94	
Mathysa ne chioride	78392	< 84	o <	50	130	77	130	45	127	
Hapitalare	91203	19	D <	50	< 50	B7	180	64	156	
	Sprnivolatile Orga	unios Adotho	a #277#P 1167	· a					90% Confidence interval	
	CAB No.	R1 – 8C – 0			R5-9C-01	Avenue Cons	Maximum Conc	Std Dev	Loper Limit	Commente
mr. n. A.T. BAN. d. a.	84742		4				330			COMMENS
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Argenia	7440382	13.	9 <	5.0	10.0	6.9	13.0	4.0	13.7	2
Ser vitium	7440117	1.3	- L	1.0		0,9	1.3	0.4	1.4	2
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tron	7430898	130	- :	1.0	\$50.0	140.3	220.0	75.D	222.0	
Selenitan	7782992			2.5	1.7	1.1	1.7	0.8	2.0	1, 2
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Sodium To	7440066	25.	- I '	1.0	10.0	26.7	51.0	20.7	91.3	2
Zinc	1 4 440000	25.	u; 5	11.03	10.0	26.7	93.0	4V./]	91.3	4

CLAUS CATALYST ROM SELFUR COMPLEX

	Continents		7	~	~
1976 Confidence Interval	Upper Limit	616.93	7.40	0.39	0.87
•	Std Dev	315.07	2.5	0.10	0.27
	Maxmum	00.00	0.50	0.38	0.00
d 784: mg/L	H5-SC-01 Averge Conc	230.00	4.67	0.28	0.38
Methods (311, 6010, 7060, 7421, 7470,7471, and 784) mg/L	H5-SC-01	25.00	09.0		< 0.10 >
10, 7060, 7421,	R4-3C-D1 R	240.00	5.70	0.38	0.63
ethode (31½, 60	Rt-SC-04	> 25.00	1.80	0.18	0.42
TCLP Metals - Me	CAS No.	74-0702	7439899	743985	7440864

Comments

Ahamintan Calcium Iron Manganese Zinc

Delection limits greater than the Nighest detected concentration are exclude of fear the calculations. Upper Lient exceeds the maximum concentration

Fiober

B. And As also detacted in the seasos ated method bank.
J. Compound's concentration is estimated. Mass spectral data indepts the presence of a compound that masteths identification criticals for which the result is less item the laboratory detection limit, but greater than zero.
ND. Not Detacted.
NA. Not Applicable.

4.0 POPULATION ESTIMATION

The numbers of people potentially exposed to the onsite and offsite management of the residuals of concern are used as input parameters in determining population risk. In addition, the race of people living near refineries is used in presenting environmental justice concerns. The approaches used to establish these input populations are presented in this section. Both the locations of specific residual management locations and the locations of refineries were used with census data to estimate these populations.

4.1 DETERMINING LOCATIONS OF INTEREST

Populations affected by the following residuals and waste management units were required for the population risk assessment:

- offsite landfills managing crude oil tank sludge
- onsite land treatment units managing crude oil tank sludge
- offsite land treatment units managing crude oil tank sludge
- onsite land treatment units managing clarified slurry oil sludge
- offsite land treatment units managing clarified slurry oil sludge
- onsite landfills managing hydrotreating catalyst
- offsite landfills managing hydrotreating catalyst
- onsite landfills managing hydrorefining catalyst
- offsite landfills managing hydrorefining catalyst.

These residuals and waste management practices were chosen on the basis of the risk assessment through both groundwater and above-ground pathways. The procedures used to establish these residuals and disposal scenarios as being of concern are presented in other background documents (e.g., "Assessment of Risks from the Management of Petroleum Refining Wastes: Background Document"). These other background documents also complete the population risk calculations, using the populations presented here as input parameters.

The determination of these locations was performed in a straightforward manner using the Section 3007 survey results. Respondents identified the locations of their onsite or offsite residual management units used in all years that they reported residual generation. To determine the locations of facilities likely to dispose of a specific residual in onsite landfills, those refineries identifying onsite landfilling of the residual in any year were extracted. A similar approach was used to identify onsite land treatment of residuals.

To establish locations of offsite landfill or land treatment facilities for the residuals, a similar approach was used for the crude oil tank sludge and clarified slurry oil sludge. That is, any facility identified by the survey as managing the residual in any year was extracted. For the hydrotreating and hydrorefining catalysts, only those offsite facilities identified as managing the residual in 1992 were extracted. The number of waste management facilities identified for each residual and each scenario is presented in Table 4.1.1.

In the cases of crude oil tank and CSO sludges, individual risks were first calculated on the basis of oily and deoiled sludges, as discussed in Section 3.1 of this document. As a result, populations and population risk were initially calculated using oily and deoiled sludges as well and qualitatively assessed for the combined categories. Table 4.1.2 presents those population estimates required for the initial assessment in terms of oily and deoiled sludges.

4.2 DETERMINING POPULATION AT LOCATIONS OF INTEREST

The locations of the facilities described above were used as inputs to population data systems to quantify the surrounding population. For each location (i.e., each refinery and offsite management unit), one, two, and five mile radii buffer zones were intersected with the Census Bureau block group demographic data. The 1 mile zones were used for the groundwater assessment from landfills. The 1 and 5 mile zones were used for the aboveground (indirect and direct) exposure assessment from land treatment units (the 2 mile zones were not used for any assessment and thus are not presented). Population risk was not required for a groundwater assessment from land treatment units, or an aboveground (indirect and direct) exposure assessment from landfills, because these scenarios were shown to present less than a 10-6 individual risk using a high end analysis. For these reasons, five mile populations surrounding landfills were not used and are not presented.

To find locations for onsite units, oil refinery locations (latitude/longitude) were initially obtained from the Federal Emergency Management Agency Master Database as an ARC/INFO point coverage. From these locations, one, two, and five mile radii buffer zones were generated using the ARC/INFO Geographic Information System buffer command.

Offsite management units were located by their zip code centroid by converting the five digit ZIP code to a latitude/longitude by means of a look-up table. This data was stored as an ARC/INFO point coverage. For each offsite management unit, one, two, and five mile radii buffer zones were also generated.

Population data was obtained from the Census Bureau Summary Tape File 1A (STF1A) database. This data was stored as an ARC/INFO point coverage for each state where each point represented the centroid of a Census block group. A block group is a polygon which nominally contains 400 housing units. Demographic statistics such as total population, age, sex, and race structure are compiled for each block group centroid.

Following this procedure, populations for some of the locations could not be obtained due to system errors, missing data, etc. For these locations, assuming a population of zero would underestimate the population. Instead, it was assumed that these facilities would have the same surrounding population as the other locations managing the specific residual. These "scaled" population data were used as the population inputs to the various assessments.

4.3 DETERMINING SUBPOPULATIONS

The populations within one mile of (1) all 171 refineries and (2) all onsite and offsite landfills and land treatment units used to manage the four residuals discussed in this chapter were determined from the same data used above. The data were segregated into the subpopulations of white and non-white. These data are presented in Table 4.3.1. For reference, the national population profile is provided as well. The population data for landfills and land treatment units does not equal the total of all units in Table 4.1.2 because persons in areas with multiple sources were only counted once (i.e., double counting was eliminated).

Table 4.1.1	. Populat	ion Profile	of Waste Ma	nagement Facilit	ies
Scenario	# of facilities	# of facilities w/ no data	Total population, i mile radius	Total population, 1 mile radius, scaled	Total population, 5 mile radius
Crude oil tank sludge, offsite landfill^	23	5	45,328	59,093	***
Crude oil tank sludge, onsite land treatment unit	16	0	34,401	34,401	1,869,556
Crude oil tank sludge, offsite land treatment unit	6	0	54,632	54,632	514,449
CSO sludge, onsite land treatment unit	8	0	21,300	21,300	842,698
CSO sludge, offsite land treatment unit	3	0	17,753	17,753	72,871
HTU catalyst, onsite landfill	5	0	1	1	~~
HTU catalyst, offsite landfill	12	3	45,379	60,505	
HRU catalyst, onsite landfill	1	0	1	1	
HRU catalyst, offsite landfill	4	0	15,758	15,758	#***

CSO sludge: clarified slurry oil sludge HTU catalyst: hydrotreating catalyst HRU catalyst: hydrotrefining catalyst

A. The population surrounding offsite landfills managing crude oil tank sludge was calculated differently than the other residuals. The calculated surrounding population is expected to overestimate the actual surrounding population by no more than 20 percent. The scaled and unscaled populations for oily and deciled sludges were summed, rather than recalculated to account for single offsite facilities receiving both subsets of this category. Populations surrounding facilities managing oily and deciled sludges are presented in Table 4.1.2.

Table 4.1.2	. Additio	nal Statistic	s for Crude a	ınd CSO Slud	ges
Scenario	# of facilities	# of facilities w/ no data	Total population, 1 mile radius	Total population 1 mile radius, scaled	Total population, 5 mile radius
Crude oil tank sludge, deoiled, offsite landfill	15	4	33,016	45,022	-
Crude oil tank sludge, oily, offsite landfill	8	1	12,312	14,071	
Crude oil tank sludge, oily, onsite land treatment unit	9	0			1,490,341
Crude oil tank sludge, oily, offsite land treatment unit	5	0			483,169
CSO sludge, oily, onsite land treatment unit	8	0	***		842,698
CSO sludge, deciled, offsite land treatment unit	2	0	44.A	***************************************	21,690
CSO sludge, oily, offsite land treatment unit	2	0	Variance		67,034

	Table 4.3.1.	Population Profiles	
	National population profile	Population profile surrounding U.S. petroleum refineries	Population profile surrounding facilities landfilling or land treating proposed listing residuals
Total population	249,402,000	651,7 5 7	195,693
White population	209,180,000	408,280	151,955
Percent white	83.9	62.6	77.6
Population of color	40,222,000	243,477	43,738
Percent population of color	16.1	37.4	22.3

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APPENDIX A 1992 RCRA §3007 Survey

Refer to docket for a copy of the RCRA §3007 Survey

APPENDIX B API Split Sample Comparison

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UNLEADED GASOLINE TANK SLUDGE

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A CONTRACTOR OF THE CONTRACTOR	7440000	190.0		3,340.0	24	1,182.0	3,300.0		
	CAS No.	R68 - US-01	Res-LES-018	R8A-US-03	RSA-LS-OFF	Average Conc	Maximum Cone	Mrchings Cone	Comment
R08 - US - 01 R09 - US - 018 R8A - US - 01 R8A - US - 019 Average Conc. Maximum Conc. Minimum Conc.	7440393	₽				I	≨	ž	N
ROB-US-01 ROBS-(183+0)(S. RSA-US-01 RBAN-118-018 Average Conc. Max/maim Conc. Min/mum Conc. ND 087 ND ND 0.40 ND NA NA NA NA NA	7440473	₽					\$		~
R08-US-01 R065-US-02 R8A-US-03 R8A-US-01 R8A-US-01 Average Conc. Max/mam Conc. Minimum Conc. NO. 087 NO. 0.49 NO. 0.001	7439626	550.0				-,	0.000		
R0B - US - 01 R0B - US - 02 R2A - US - 03 R2A - US - 04 R2A - US - U	7439021	0.03	Q.088				20.0		
R0B-US-01 R0B-US-02 R0B-US-03 R0B-US-019 Average Conc. Maximum Conc. Minimum	7439965	7.30					7.30	5.7	
ROB - US - O1 ROB - US - U	7460020	6.70		v			90.00	0.20	
ROB - US - O1 ROB - US - U	-		* 1.00% 11.000 M		7.0000000			_	

Aumereum
Arabnony
Arabnony
Arabnony
Codomium
Corpor
Copper
Copper
Lead
Mangenese
Mercuy
Morkedenum
Varastium
Zinc

Comments:

Barlum Chromlum Iron Lead Mangeness Nickel

Detaction links greater than the highest detacted concernation are excluded from the oxidualizans. Analyte not detected with EPA this, but reported with API team.

Notes

110 ¬

Analyte also detected in thesesocialized method blank.
Compound's concentration's estimated. Mass apactes deta indicats the presence of a compound that meets the identification critical accompanies result is less than the inbonsiony detection limit, but greater than zero.
Not Detected.
Not Applicable.
Not Applicable.

9 ≨ ⊊

Minimum Conc. 1,250 1,250 1,250 1,250 1,250 1,250 1,250 1,250 1,250 1,250 1,250 1,10

	Voletie Cyclinates - Mathod 6260A politic	- Mathod 6260 54 50 51	Apollo	6	0.E	1	
	CAS PER	1010 · 111	2	D-00-184		1 SAS	
Monte of the second	214/2	98	3	, -,	(0) (0) (1) (1) (1)	200	200
	\$15W21	1,250		000	3	10,513	22,000
Bar-But-But-But-	1359GB	1,250		v		999	900
Egradonica	*1.003	1,250		₩		986.0	20.500
(economy/204n/204ne	2002	× 1,250	C	٧	•	962,1	2,900
p - keoprogagananene	2,000	4,250		v		8	2,600
Nestheren	10013	2,900	20024			43,225	140,000
n-Propylibenziere	149601	1,250				1,925	2,700
Totalene	£39903	3,900				10,850	17,000
1,2,4—T(bredhylbertene	9699	11,000	3	•		9000	140,000
1,3,5-Trimeflythenene	9/9901	2,000				86,2	300
o - Xplens	85478	3,000				10,375	00000
er, p—Xy lemes	108369 / 106423	1,000		19,000	000	49,750	100,000
	TO PVoteble On	series - Matrio	Co. Postate Organica - Methods 1311 and 82804 soul	t work			
	CAS No	R4-80-03	HA-SEC-OTE	RF- 80 -01	RE-CE-ER	AMERICAN CORP. MANSTONIA CORP.	Australia Coro Mi
Acarona	87641	٧		.v		2	_
Berma	71430	٧	7	~	. 1000 1000 1000 1000 1000 1000 1000 100	28	3
Matteriene oficide	750065	٧	•	2	E	2	8
Naph fraish	21203	v	*	28		101	200
Total	10883	6	2	\$		Ę	240
1.2.4Trimethylbenzane	85630	%	\$	S	14 14 14 14 14	2	01.3
O-Mylene	8547B	01	5	S		ន	2
the state of the s	106363 / 106423	22	E	8		<u>\$</u>	<u> </u>
	Saminolatio Creation - Mathematical 30 70% and	tolos - Method	APTOR under				
	CAS NO	R4-80-01	R4-80-918	P4-80-D	810±08168	Average Conc.	Measimum Cono Mil
Acanachitene	97000	< 61,875	V	£6,000 J		80,210	160,000
Antraceste	(2012)	× 81,675 ×	e Ng		-		0000
Special a) action acoust	2533	300,000				M	300,000
Secrofivorantiers (lots)	≨	110,000		_		2	110,200
Hearo(g, F, g) peylers	:D:242	00000	200			200	100,000
Hard Sold (a) Colored	200	200,000	0.00 940 940 940	_			
Christoph		× 12.72			•		1000
Oxygene 2	21804	onn'nn	2 S	ODE OF		200,000	200
	9766	× ×			•	100	0.00
7 49 - Dioxedhydenzialandanae	S/M/A	A \$1,875	1200 1000 1000 1000 1000 1000 1000 1000	1,298,000	•	330,908	1 200,000
Francisco	3007	J 43,000				82,500	130,000
Figures	75C00	A 51,675	164,000	_	200	111,400	200,000
Indeno(1,2,3-ed)pyrene	\$9000E	× 81,875			5	23,313	24,000
9 - Mathylohokenthamon	20405	× 01,675		¥	£ !	27,613	27,000
2 - Medhylchiyaene	3.061324	•		•			000700
t - Medingstrapt draws as	6. 6.	· ·	140,040		 		2.200.000
2-Methydraphthalens	E-946	00008		•		282,620	3,600,000
2 - Marty Walter Co	378	2000	E \$	v 1	5 5	24.417	
254 - Marity Chiercol (15/53)	≨	7		ų		714 VZ	OF COMPANY
	200	200,000	3	00000			2000
	1000	T TOO GO		-		•	OLG BO
Prend	Olivos:	,	902'90	•	•	005.500	000
	_				_		

14,000 14,000 15

<u> គួនខុខ ទិនី ខេស្ត់</u> និ

8 2882833855

| TCLP Sembratelle Organics - Methods 134 and 82709 pgt. | Rfs-IID.-D16 Asset | Rfs-IID.-D16

314(2—ethylicatyl)phthelate 21—n—bury; prifysiasa 1—deaty; prifysiasa 1—deaty; praychibalana 2—beaty; praychibalana 2—beaty; praychibalana 2—beaty; praych 2—beaty; praych Naphthelana Naphthelana Phemanthosna

Alumenum	Marganese
Antimory	Marganese
Sertum	Nickel
Celetum	Potassium
ron	Zino

	TEST COLOR	(100), (421, (4/U, 74)	Ti and Set may	W				
CA8 #20	24-50-6	# - TE	188-SO-61	M6-80-018	Arestago Cono.	Mandaum Cong	Marian Good	Commiss
3420905	800	200	22,000	8	27,72	000	2,000	
3440000	*	.//. V	940.0	8	239.5	C'OPE	0.0	
7440362	w) V		4.7	2	2.0	7.4	1.0	-
7440393	450.0	288	48.0	42.7	20,	170.0	0.04	
7440417	-	V	V 0.5	2	03	1.2	0.5	
340639	2		9	8	ž	*X	*	67
3440702	1,100	30	> 500.0	*	28,525.0	0.000,003	500.0	
340473	*		**		48	3	6.4	
1440454	Z		2	7	ž	ž	Ž	4
3440908	æ		7.8	· ·	23.5	2	P.	
3430696	000		2,400.0	4	Q.K.	1,000.0	2400.0	
143052	ន	4.	17.0	***	8	47.0	17.0	
7430254	905 Y		2000	•	2375.0	7000	2000	
3439965	8		15.0	***	76.8	240.0	15,0	
143007d	0.11	<u>¥</u>	< 0.05		0.07	0.11	0.1	
7430667	•		99	*	4	180.0	6	
34400030	300		120.6	8	180.5	300.0	000	
7440097	900	/	> 800.0	9	1125.0	11,000,0	0.005	
2040407			***	9		4	2	
1640235	12000	9	1,700.0	9	0.505.0	62000	0.00041	
CACTILAT	1		-	g	7	**		
766/000	,		200	į				
700			200	*	27.7.0	7		
140808	ğ		24.0		\$5.0	1000	<u>v</u>	
TAY D Edulade - In	Confliction (1946)	25 2012 WATER 2108	757 4 and 74	·				
CAS len		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		SO BUILDIN	America Cono	Mandmin Conn	Minfaster Cone	Change
MOORE					283	200		
3440250	2	vod	9	56	ž	1	7	**
1440093	2	0	9	70	× ×	3	ž	
CONTONIA	280		2500		# 1.43 74	4 500 000	8	ı
1430001			5	9	2		5	
7500674	,		× ×	9	74.74	9	200	
7430065			200	1	1.24	7.40		
TAMORE		9					3 8	
			,		9.0		1 5	
7400E/	V		8	5	62.83	00.00	88.88	
74088	0,2	¥	o.10j	5	0.21	0.37	0.0	

Carment

Defection limits greate than the highest detached concentration are zactorized from the calculations. Analyse not detached with EPA data, but reported with AFI data.

NG94

6 7

Anayta also described in the east-ortaledmethood blank.

Compound a concessibation is sestimated. Mass specifical sindicate the presence of a compound that meet the identification selected the result is less than the laboraboy detection timit, but grasher than perc.

Not belocated.

Not applicable.

95

FCC EQUILIBRIUM CATALYST

	Volatile Organics -	 Method 8260/ 	A μg/kg						
	CAS No.	R4-FC-01	R4-FC-018	R6-FC-01	R6-FC-018	Average Conc	Maximum Conc	Minimum Cons	Comments
Chloroethane	75003	NO	NO.	NO.	J 520	NA	NA	NA	2
Acetone	67641	ND	2,400	ND	ND	NA	NA	NA	2
Benzene	71432	NO	660	ND	NO	NA	NA	NA	2
n – Butylbenzene	104518	NO	J 320	ND	ND	NA	NA	NA	2
Ethylbenzene	100414	6,400	4,600	< 570	ND	3,485	6,400	570	-
Isopropylbenzene	98828	NO	J 350	ND	ND	NA.	NA	NA	2
n - Propylbenzene	103651	2,200	1,200	< 570	ND	1,385	2,200	570	
Toluzne	108883	17,000	14,000	< 570	ND	8,765	17,000	570	
1,2,4-Trimethylbenzene	95636	13,000	9,100	1,300	ND	7,150	13,000	1300	
1,3,5 - Trimethylbenzene	108678	5,100	3,500	< 570	ND	2,835	5,100	570	
o-Xylene	95476	11,000	8,100	< 570	ND ND	5.785	11,000	570	
m,p-Xylenes	108383 / 106423	35,000	18,000	< 570	ND	17,785	35,000	570	
Methyl ethyl ketone	78933	1,400	NR	< 570	NR	985	1,400	570	
Methylene chloride	75092	ND	BJ 390	ND	J 140	NA	NA	NA.	2
Naphthalene	91203	< 625	1,200	3,000	ND	1,813	3,000	625	
		· ·	7 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	,		'	•	,	
	TCLP Volstile Org	janics - Method	is 1311 and 8260A	/g/L					
	CAS No.	R4-FC-01	R4-F0-018	R6-FC01	R6-FC-018	Average Conc	Maximum Conc	Minimum Conc	Comments
Acetone	67641	100	NA	< 50	NA	75	100	50	
Toluene	108883	B 160	NR NR	< 50	NR	105	160	50	
m,p - Xylenes	108383 / 106423	B 150	NA	< 50	NR	100	150	50	
Methyl ethyl ketone	78933	150	NA	< 50	NR	100	150	50	
		·		_			•	,	
	Semivolatile Orga	inics - Method	8270B µg/kg						
	CAS No.	R4-FC-01	R4-FC-018	R6-FC-01	R6-FC-01S	Average Conc	Maximum Conc	Mir/mum Conc	Comments
Benz(a)anthracene	56553	NO	NO.	ND	J 38	NA	NA	NA	2
Chrysene	218019	NO	ND	ND	J 190	NA	NA	NA	2
Dibenz(a,h)anthracene	53703	NO	NO	ND	J 42	NA	NA	NA	2
Dibenzoluran	132649	ND	NO	ND	J 95	NA	NA	NA	2
Fluoranthene	206440	NO	NO NO	ND	J 37	NA	NA	NA	2
Fluorene	86737	NO	NO NO	ND	J 190	NA.	NA	NA	2
t - Methylnaphthalene	90120		460	< 165	620	568	510	165	
2 – Methylnaphthalane	91576	.870	810	< 165	600	923	870	165	
Naphthalene	91203	670	620	< 165	1,300	728	670	165	
1.4-Naphthoquinone	130154	NO	NO	ND	J 130	NA	NA	NA	2
Phenanthrene	85018	NO	NO NO	ND	5,300	NA	NA	NA	2
Di – n – butyl phthalate	84742	< 165	NR	1,000	J 33	583	1,000	165	
	,						•	·	
	TCLP Semivolatile	o Organics – M	ethods (311 and 82)	70B µg/L					
	CAS No.	R4-FC-01	R4-FC-018		R6-FC-015	Average Conc	Maximum Conc	Minimum Conc	Comments
Bis (2-ethylhexyl)phthalate	117817	JB 23	NA	J 15	NA	19	23	15	
		,							

FCC EQUILIBRIUM CATALYST

	Total Metals - Met	thods 6010, 7060	, 7421, 7470, 7471	. and 7841 mg	/kg				
	CAS No.	R4-FC-01	R4-FC-01S	R6-FC-01		Average Conc	Maximum Conc	Minimum Conc	Comments
Aluminum	7429905	89,000.0	49,000	31,000.0	19,200	60,000.0	89,000.0	31,000.0	
Antimony	7440360	ND	NO	NO	50,1	NA	NA	NA	2
Areenic	7440382	< 1.0	ND	2.5	ND	1.8	2.5	1.0	_
Barlum	7440393	190.0	122	< 20.0	21,6	105.0	190.0	20.0	
Berylilum	7440417	2.7	NO	1.7	1,1	2.2	2.7	1.7	
Cadmlun	7440439	ND]	ND	ND	8	NA.	NA	NA.	2
Calcium	7440702	1,700.0	NR .	< 500.0	NR	1,100.0	1,700.0	500.0	
Chromium	7440473	17.0	10.2	4.0	5.3	10.5	17.0	4.0	,
Coball	7440484	< 5.0	4.7	18.0	23.2	11.5	18.0	5.0	
Copper	7440508	19.0	10.4	13.0	14	16.0	19.0	13.0	
(ron	7439696	4,800.0	NR	1,000.0	NR	2,900.0	4,800.0	1,000.0	
Lead	7439921	42.0	38.7	11.0	11,1	26.5	42.0	11.0	
Manganese	7439965	32.0	20.3	< 1.5	4.9	16.8	32.0	1.5	
Malybdenum	7439987	ND	3.5	ND	9,6	NA	NA	NA	2
Nickel	7440020	330.0	187	91.0	117	210.5	330.0	91.0	
Sodium	7440235	0.008,9	NR	1,900.0	NR)	5,850.0	9,800.0	1,900.0	
Thallium	7440280	ND	0.58	ND	NR	NA	NA	NA	2
Vanadium	7440622	1,200.0	823	720.0	978	960.0	1,200.0	720.0	
Zinc	7440666	68,0	36	9.3	11,9	38.7	68.D	9.3	
	TCLP Metals - Me CAS No.	R4-FC-01	R4-FC-018	R6-FC-01	R6-FC-018	•	Neximum Conc	Minimum Conc	Comments
Antimony	7440360	< 0.30	NA	2.00	2.1	1.15	2.00	0.3	

Antimony Barium Chromium fron Nickei Vanadium Zinc

Comments:

7440393

7440473

7440622

7440666

7439896 <

7440020 <

1 Detection limits greater than the highest detected concentration are excluded from the calculations.

ND

ND

1,30

1,10

0.85

0.10

2 Analyte not detected with EPA data, but reported with API data.

0.17

0.016

NR

NR

NR

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.

0.25

ND

NR

NR

NR

NA

NA

0.90

0.65

5.18

0.18

NA

NA

130

110

950

025

NA

NA

0.5

0.2

0.9

0.1

2

2

- ND Not Detected.
- NA Not Applicable.

ND

ND

0.50

0.20

9,50

0.25

NR Not Reported, or concentration below the method detection limit.

FCC EQUILIBRIUM CATALYST FINES

	Volatile Organics -	 Method 8260/ 	A μg/kg									
	CAS No.	R2-FC-01	R2-FC-018	R4-FC-02	R4-FC-028	R5-FC-02	R5-FC-028	R6-FC-02	R6-FC-028	Average Cono Maximum Co	nc Minimum Conc	Comments
Acetone	67641	ND.	ND	NO	NO.	ND	40	ND	B 52		IA NA	2
Benzene	71432	ND	J 180	ND	VD.	ND	NO	ND	ND		MA NA	2
Carbon dirutilde	75150	ND.	NO.	NED	NO.	NO.	1.6	ND	NO		IA NA	2
Ethylbenzine	100414	ND	600	NO	NO.	ND	ND.	ND	NO.		AN NA	2
Mathylena chibrida	75092	ND	J 170	NO B		ND	NO.	ND	ND		AN AN	2
n-Propylbanzana	103651	ND		NED	NO.	ND	ND	ND	NO		NA NA	5
Tokiens	108883	1,400	948	c 5		< 5	ND	c 5	NO		oc s	-
1,2,4-Trimettylbenzene	95636	ND		NED	NO	ND	NO	ND	NO		NA NA	2
1,3,5-Trimethylbenzene	108678	ND	J 110	NO	NO.	NO.	NO	ND	NO		NA NA	2
o-Xviene	95476	ND	J 490	NO	NO.	ND	NO.	ND	NO NO		NA NA	2
m.pXylenes	106383 / 106423	1,500	560	c 5	NO.	. 5	NO	< 5	NO	379 1.0	00 S	_
	TCLP Volatile Org				\$20,000,000,000,000,000,000,000						•	
	CAS No.	R2-FC-01			R4-FC-028	R5-FC-02	AL-FC-028	R6-FC-02		Average Conc Maximum Co		Comments
Methylene chloride	75092	< 50	NR ·		MR. I		NF)	< 50	NA		40 50	
Toluene	108663	< 50	NR 6		, , , , , , , , , , , , , , , , , , , ,	c 50	1	< 50	NFR:		50 50	
o-Xylena	95476	< 50	NR E			< 50		< 50	NR	59	87 50	
m,p—Xylenes	108363 / 106423	< 50	NR E	210	NR	c 50	NR	< 50	NR	90	10 50	
	i i											
	Semivolatile Orga											
	CAS No.	R2-FC-01	R2-FC-018	R4-FC-02	R4-FC-028	R5-FC-02	R6-FC-028	R6-FC-02		Average Conc. Maximum Co		Comments
Bis (2 – ethylhexyl) phthaleta	CAS No. 117817	R2-FC-01 J 250	R2→FC→018 ND	185		< 165	560	J 110	J 34	173	50 110	Comments
2-Methylnaphthalene	CAS No. 117817 91576	R2-FC-01 J 250 < 165	R2→FC→018 ND ND	c 165 c 165		< 165 J 81	560 1 01	J 110 J 170	J 34 J 250	173 2 126	50 110 70 81	Comments
2 - Mothylnaphthalone 1 - Methylnaphthalone	CAS No. 117817 91576 90120	R2-FC-01 J 250 < 165 < 330	R2-FC-018 NO NO	c 165 c 165 c 330	999	< 165 J 81 J 85	560 J 91 J 67	J 110 J 170 J 150	J 34 J 250 J 190	173 126 118	50 110 70 81 50 85	Comments 1 1
2-Methylnaphthalene 1-Methylnaphthalene Benz(s)anthracens	CAS No. 117817 91576 90120 56553	R2-FC-01 J 250 < 165 < 330 < 165	R2-FC-018 ND ND ND ND	< 165 < 165 < 330 < 165	10 10 10	< 165 J 81 J 85 J 70	\$60 J 91 J 67 J 69	J 110 J 170 J 150 < 165	J 34 J 250 J 160 ND	173 2 126 1 118 1	50 110 70 81 50 85 76 76	1 1 1
2 Methylnaphthalene 1 Methylnaphthalene Benz(a)anthracens Benzo(a)pyrene	CAS No. 117817 91576 90120 56553 50328	R2-FC-01 J 250 < 165 < 330 < 165 ND	H2-FC-018 ND NO NO ND ND	< 185 < 185 < 330 < 185 ND	66666	< 165 J 81 J 85 J 79 ND	560 J 01 J 67 J 69 J 69	J 110 J 170 J 150 < 165 ND	J 34 J 250 J 190 ND	173 126 118 76 NA	50 110 70 61 50 65 76 76 NA NA	Commente 1 1 1 2
2-Mothylnaphthalene 1-Mathylnaphthalene Benz(a)anthraoena Benzo(a)pyrene Chrysene	CAS No. 117817 91576 90120 50553 50328 216019	R2-FC-01 J 250 < 165 < 330 < 165 ND < 165	R2-FC-018 NO NO NO NO	165 165 330 165 ND	55555	< 165 J 81 J 85 J 70 ND	560 91 67 60 59	J 110 J 170 J 150 < 165 ND < 165	J 84 J 250 J 190 ND ND	173 126 116 76 NA 171	50 110 70 81 50 85 76 76 NA NA	1 1 1
2-Mothylnaphthalene 1-Mothylnaphthalene Benz(a)anthracene Benzo(a)pyrene Chysene CN-n-bulyi phthalate	CAS No. 117817 91576 90120 56553 50328 218019 64742	R2-FC-01 J 250 < 165 < 330 < 165 ND < 165 < 165	R2-FC-018 NO NO NO NO NO NO NO NO NO NO NO NO NO	c 165 c 165 c 330 c 165 ND c 165 c 165	366666	(165 J 81 J 85 J 70 ND J 190 J 180	082 10 10 78 10 00 00 00 00 10 10 10 10 10 10 10 10	J 110 J 170 J 150 < 165 ND < 165 < 165 < 165	J 54 J 250 J 160 ND ND NO NR	173 126 116 76 NA 171 169	50 110 70 81 50 65 76 76 NA NA 90 165 80 165	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)spirenene Benzo(a)spirene Chysene Chysene Phur bulyi phthalate Fluorene	CAS No. 117817 91576 90120 50553 50328 216019 64742 86737	R2-FC-01 J 250 < 185 < 330 < 165 ND < 165 < 165 ND	R2-FC-018 199 199 199 199 199 199 199 199	c 185 c 165 c 300 c 185 MD c 185 c 185	536666	K 165 J 81, J 85, J 76, ND, J 190, J 180	\$60 91 67 69 59 1 140 NFI	J 110 J 170 J 150 < 165 ND < 165 < 165 ND	J 54 J 250 J 190 J 190 ND ND ND ND	173 126 116 76 NA 171 189 NA	50 110 70 81 50 85 76 76 NA NA 90 165 80 165 NA NA	1 1 1
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)anthracene Benzo(a)pyrene Chrysene CH-n-bulyi phthaliste Fluorene Phonenshana	CAS No. 117817 91576 90120 50553 50328 218019 64742 86737 65018	R2-FC-01 J 250 < 185 < 330 < 165 ND < 185 < 165 ND	R2-FC-018 NO	c 185 c 165 c 330 c 185 ND c 185 c 185 c 185	6536666	< 165 J 81 J 85 J 76 J ND J 190 J 180 ND S70	\$60 01 01 07 09 59 140 NFI 28 810	J 110 J 170 J 150 < 165 ND < 165 < 165 NO < 165	J 94 J 250 J 160 HD HD HD HD HD HD	173 126 116 76 NA 171 189 NA 266	550 110 70 81 50 85 76 76 NA NA 90 165 80 105 NA NA	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)anthracene Benzo(a)pyrene Chrysene (N-n-bulyi phthalate Fluorene Phenanthana Pyrene	CAS No. 117817 91876 90120 56553 56336 218019 64742 86737 85018	R2-FC-01 J 250 < 165 < 330 < 165 ND < 165 < 165 < 165 < 165 < 165	R2-FC-018 ND ND ND ND ND ND ND ND ND ND ND ND ND	c 185 c 165 c 330 c 185 ND c 185 c 185 c 185 c 185	668366666	< 165 J 81 J 85 J 76 J 76 ND 190 ND 180 ND 76 ND 77	\$60 91 97 9 69 50 140 MF 38 510	J 110 J 170 J 150 < 165 ND < 165 < 165 < 165 < 165	J 250 250 100 200 100 100 100 100 100 100 100 10	173 126 116 76 NA 171 100 NA 206	5C 110 7C 81 5C 65 7E 76 VA NA 0C 165 8C 165 8C 165 VA NA 7C 165 7C 76	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)pyrene Benzo(a)pyrene Chysene Chysene Phonebuje phthalate Fluorene Phonesthana Pyrene Pyridne	CAS No. 117817 91574 90120 50553 50328 216019 84742 86737 85018 129000 110881	R2-FC-01 J 250 < 155 < 330 < 165 MD < 165 < 165 < 165 < 165 < 165	R2-FC-018 ND ND ND ND ND ND ND ND ND ND ND ND ND	C 185 C 330 C 330 C 185 ND C 185 C 185 C 185 C 185 C 185 C 185	366536666	165 J 81 J 85 J 76 ND J 190 J 180 ND S70 J 78	\$60 01 01 67 69 59 140 NR 38 810	J 110 J 170 J 150 < 165 ND < 165 < 165 < 165 < 165 < 165 < 330	J 34 J 250 J 160 ND ND NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG N	173 126 118 76 NA 171 100 NA 206 76	550 110 70 81 50 85 76 76 78 76 NA NA 00 165 80 165 80 165 NA NA 70 165 70 70	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)anthracene Benzo(a)pyrone Chysene Chi-n-bulyi phthalate Fluorane Phrenanthana Pyrene Pyridine 2-Methylchrysene	CAS No. 117817 91576 90120 56553 50326 216019 64742 66737 65018 129000 110861 3351324	R2-FC-01 J 250 < 185 < 330 < 165 ND < 165 < 165 < 165 < 165 < 330 < 330	R2-FC-018 NO NO NO NO NO NO NO NO NO NO NO NO NO	C 165 C 105 C 330 C 165 MD C 165 C 165 C 165 C 165 C 165 C 330 C 330	33665566666	C 165 J 81 J 85 J 79 ND J 160 J 180 MD S70 J 78 J 78 J 77	\$60 91 87 69 59 140 NR 938 \$10 71 NR	J 110' J 170 J 150 < 165 ND < 165 NO < 165 NO < 165 < 330 < 330 < 330	J 250 250 1 160 20 20 20 20 20 20 20 20 20 20 20 20 20	173 126 116 76 NA 171 169 NA 266 76 350	550 110 70 81 50 85 76 76 NA NA 90 165 80 165 NA NA 70 165 70 76 106 330 77 77	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)pyrene Benzo(a)pyrene Chysene Chysene Phonebuje phthalate Fluorene Phonesthana Pyrene Pyridne	CAS No. 117817 91574 90120 50553 50328 216019 84742 86737 85018 129000 110881	R2-FC-01 J 250 < 155 < 330 < 165 MD < 165 < 165 < 165 < 165 < 165	R2-FC-018 ND ND ND ND ND ND ND ND ND ND ND ND ND	C 185 C 330 C 330 C 185 ND C 185 C 185 C 185 C 185 C 185	366536666	165 J 81 J 85 J 76 ND J 190 J 180 ND S70 J 78	\$60 01 01 67 69 59 140 NR 38 810	J 110 J 170 J 150 < 165 ND < 165 < 165 < 165 < 165 < 165 < 330	J 34 J 250 J 160 ND ND NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG N	173 126 116 76 NA 171 189 NA 286 76 350	550 110 70 81 50 85 76 76 78 76 NA NA 00 165 80 165 80 165 NA NA 70 165 70 70	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)anthracene Benzo(a)pyrone Chysene Chi-n-bulyi phthalate Fluorane Phrenanthana Pyrene Pyridine 2-Methylchrysene	CAS No. 117817 91576 90120 56553 50326 216019 64742 66737 85018 129000 110861 3351324	R2-FC-01 J 250 < 165 < 330 < 165 ND < 165 < 165 < 165 < 165 < 330 < 330 < 330	82-FC-018 ND-100	c 185 c 185 c 330 c 185 c 185	5556555665666	C 165 J 81 J 85 J 79 ND J 160 J 180 ND S70 J 78 J 78 J 77 NO	\$60 91 87 69 59 140 NR 938 \$10 71 NR	J 110' J 170 J 150 < 165 ND < 165 NO < 165 NO < 165 < 330 < 330 < 330	J 240 J 250 J 160 ND ND ND ND ND ND NB NB	173 126 116 76 NA 171 169 NA 266 76 350	550 110 70 81 50 85 77 76 78 NA NA 90 105 80 105 NA NA 70 105 77 76 100 330 77 77 NA NA	1 1 1 2
2-Mothylnaphthalene 1-Methylnaphthalene Benz(a)anthracene Benzo(a)pyrone Chysene Chi-n-bulyi phthalate Fluorane Phrenanthana Pyrene Pyridine 2-Methylchrysene	CAS No. 117817 91576 90120 50533 50328 218019 84742 86737 85018 129000 1108811 3351324 91203	R2-FC-01 J 250 < 185 < 330 < 165 ND < 185 < 165 < 165 < 165 < 165 < 185 < 330 < 330 < 300 ND	82-FC-018 ND-100	185 (165 (330 (185 (33665566666	C 165 J 81. J 85. J 76. ND. J 190 ND. S70 J 76. J 77 ND. J 77 ND. RS-FC-02	\$60 91 87 69 59 140 NR 38 810 71 NR NR	J 110' J 170 J 170 J 150 C 165	J 250 J 160 J 160 ND ND NB	173 126 116 76 NA 171 160 NA 266 76 350 77 NA	550 110 70 81 50 85 77 76 78 NA NA 90 105 80 105 NA NA 70 105 77 76 100 330 77 77 NA NA	1 1 1 2 2

FOC EQUILBRIUM CATALYST FINES

Aluminum
Antmony
Arsenic
Barium
Beryllum
Cadmium
Calcium
Chromium
Cobalt
Copper
Iran
Lead
Manganese
Molybdenura
Nickel
Selenium
Sodium
Thellum
Vanadure
Zino

Atumbuum Animony **Barlum** Calcium Chromlum Cobalt Copper hon Lead Manganese Mercury Nictori Vanadium Zino

CAS No.	R2-FC-01	R2-FC-018	R4-FC-02	R44FC-028	H\$-FC-02	R5+FC+028	R8-FC-02	R0-FC-028	Average Cono	Maximum Conc	Minimum Conc	Comments
7429905	120,000.0	88,200	73,000,0	53,800	54,000.0	42,500	17,000.0	19,200	\$6,000.0	120,000.0	17,000.0	
7440360	47.0	121	< 5.0	ND ND	< 6.0	ND	< 8.0	NO	16.3	47.0	0.0	
7440382	11.0	1,1	< 1.0	NO.	2.2	D.68	3.3	1.9	4.4	11.0	1.0	
7140393	160.0	95.4	590 .0	401	55.0	39.0	210.0	260	253.8	590.0	55.0	
7140417	13.0	0.89	1.8	0.34	< 0.5	0.96	< 0.5	0,41	4.0	13.0	1.5	
7140439	ND ND	ND	ND	NO.	NO	0.50	NO	0.71	NA.	NA	HA	2
7140702	1,500.0	NR.	2,600.0	M	2,100.0	NR.	1,400.0	NR.	1,960.0	2,600.0	1,400.0	
7440473	42.0	17.2	57.0	45.5	15.0	15,1	43.0	47.4	39.3	57.0	15.0	
7140484	28.0	15.4	18.0	14.5	< 5.0	5.3	80.0	88,7	32.8	80.0	\$.0	
7440508	23.0	19.9	64.0	62.7	6.9	5.9	19.0	21.6	28.2	64.0	8.9	
7439898	6,000.0	NR.	34,000.0	NR.	1,500.0	NA NA	11,000.0	NA.	13,150.0	34,000.0	1,600.0	
7439921	34.0	11.8	210.0	41.3	7.2	4.7	8.4	6.1	64.9	210.0	7.2	
7439965	28.0	19.9	100.0	69.3	\$1.0	9.0	64.0	71.4	50. 6 .	100.0	11.0	
7139087	c 0.5	9.1	20.0	22.1	< 6.5	2	< 0.5	S	9.9	20.5	4.5	
7440020	900.0	317	780.0	504	73.0	59.3	130.0	145	470.6	9,00,0	73.0	
7782492	< 0.5	NR.	3.6	NB.	< 0.5	NR	< 0.5	NR	1.3	3.5	0.5	
7440235	2,300.0	NR.	5,000.0	NR NR	14,000.0	NR.	9,700.0	NA.	7,750.0	14,000.0	2,300.0	
7440250	< 1.0	NFR.	3.2	2.2	< '.0	NR	< 1.0	NA	1.6	3.2	1.0	
7440022	2,600.0	1,230	670.0	581	110.0	105	230.0	247	902.5	2,600.0	110.0	
7440000	79.0	84.5	300.0	230	22.0	20	91.0	112	123.0	300.0	22.0	
	Methods 1311, 60				Bt_cc_m	96.50.008	Ba_fC_m	D#EC038	Awarana Conn	Marinum Cone	Minimum Coso	Common
CAS No.	R2-FC-01	R2-FC-018	R4-FC-D2	#4+FC-028	R5-FC-02	R6-FC-028	R5-FC-02			Maximum Cono	Minimum Conc	Comment
CAS No. 7429905	R2-FC-01 110.00	R2-FC-018	R4-FC-02 410.00	A4+FC+028 NR	< 1.30	NR	4.30	NA.	191.33	410.00	1.0	Comment
CAS No. 7429905 7440360	R2-FC-01 110.00 0.69	R2-FC-018 NR NR	R4-FC-02 410.00 < 0.30	94-FC-028 NR NR	< 1.30 < 0.30	NR 2.3	4.30 < 0.30	NA NO	191.33 0.45	410.00 0.89	10 03	
CAS No. 7429905 7440360 7440393	R2-FC-01 110.00 0.69 ND	R2-FC-018 NR NR 0.14	R4-FC-02 410.00 < 0.30 NO	R4-FG-028 NR NR 0.017	< 1.30 < 0.30 ND	NR 2.3 0.26	4.30 < 0.30 NO	NA ND 0.11	191.33 0.45 NA	410.00 0.89 NA	1.0 0.3 NA	Comment 2
CAS No. 7429905 7440360 7440393 7440702	R2-FC-01 110.00 0.89 AD < 25.00	R2-FC-018 NR NR 0.14 NR	84-FC-02 410.00 < 0.30 NO 100.00	94-FC-028 NR NR 0.017	< 1.30 < 0.30 MD 58.00	NR 2.3 0.26 NR	4.30 < 0.30 NO 58.00	MA ND 0.11 MA	131.33 0.45 NA 60.25	410,00 0.89 NA 100.00	10 03 NA 250	
CAS No. 7429905 7440360 7440303 7440702 7440473	R2-FC-01 110.00 0.89 ND < 25.00 0.24	R2-FC-018 NR NR 0.14 NR 0.007	R4-FC-02 410.00 < 0.30 ND 100.00 0.34	914-FC-028 NR NR 0.017 NR 0.074	< 1.30 < 0.30 ND 58.00 < 0.05	NR 2.3 0.26 NR ND	4.30 < 0.30 ND \$8.00 < 0.05	NR ND 0.11 NR 0.001	191.33 0.45 NA 60.25 D.17	410.00 0.89 NA 100.00 0.34	10 03 NA 250 01	
CAS No. 7429905 7440360 7440393 7440702 7440473 7440484	R2-FC-01 110.00 0.69 ND < 25.00 0.24 < 0.25	R2-FC-018 NR NR 014 NR 0.007 NR	R4-FC-02 410.00 < 0.30 ND 100.00 0.34 < 0.25	94-FC-028 NR NR 0.017 NR 0.074 NR	< 1.30 < 0.30 ND 58.00 < 0.05 < 0.25	23 28 28 29 29 29	4.30 < 0.30 ND 58.00 < 0.05 0.72	NA 0.11 NA 0.001	191.33 0.45 <i>NA</i> 60.25 0.17 0.37	410.00 C.89 NA 100.00 0.34 0.72	10 03 MA 250 01	
CAS No. 7429905 7440360 7440393 7440702 7440473 7440464 7440506	R2-FC-01 110.00 0.59 ND < 25.00 0.24 < 0.25 0.40	R2-FC-018 NR NR 9.14 NR 0.007 NR NR	R4-FC-02 410.00 < 0.30 NO 100.00 0.34 < 0.25 0.33	94-FO-628 NR NR 0.017 NR 0.074 NR	< 1.00 < 0.30 ND 58.00 < 0.05 < 0.25 < 0.13	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	4.30 < 0.30 ND \$8.00 < 0.05 0.72 < 0.13	96 0.11 96 9.001 96 96	191.33 0.45 NA 60.25 0.17 0.37	410,00 C.89 NA 100,00 0.34 0.72 0.40	10 03 NA 250 01 03	
CAS No. 7429905 7440360 7440393 7440702 7440473 7440484	R2-FC-01 110.00 0.69 ND < 25.00 0.24 < 0.25	R2-FC-018 NR NR 014 NR 0.007 NR	R4-FC-02 410.00 < 0.30 ND 100.00 0.34 < 0.25	94-FC-028 NR NR 0.017 NR 0.074 NR	< 1.30 < 0.30 ND 58.00 < 0.05 < 0.25	23 28 28 29 29 29	4.30 < 0.30 ND 58.00 < 0.05 0.72	NA 0.11 NA 0.001	191.33 0.45 <i>NA</i> 60.25 0.17 0.37	410.00 C.89 NA 100.00 0.34 0.72	10 03 MA 250 01	Comment

NO

0.79

0.25

16.00

0.42

NR

ND

NR

NR NR <

0.01

2.97

1.41

5.37

NA

NO

NA

NP

0.00038

2.70

7.50

4.90

16.00

NA

02

NA 02

0.3 0.3

2

Comments:

7439965

7439970

7440020

7440822

7440000

1 Delection limits greater than the highest detected concentration are excluded from the calculations.

2.70

ND

7.50

0.25

2 Analyte not detected with EPA data, but reported with API data.

NR

NO NE NE NE NE

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is settimated. Mass spectral data indicate the presence of a compound that neets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.

NF

NO NF NF NF

0.15

ND

0.20

0.25

0.28

ND Nat Detected.

0.33

NĐ

3.40

4.90

0.61

- NA Na Applicable
- NR Not Reported, or concentration below the method detection imit

HYDROTREATING CATALYST

	Volatile Organice	- N	Aethod 8260A	μαλέα				
	CAS No.		R1-TC-01	R1-TC-018	Average Cono	Maximum Cono	Minimum Cono	Commente
Benzane	71432		500,000	1,900,000	110,383	500,000	2,000	
n-Butylbarzene	194518	<	12,500	ND	11,571	50,000	500	
sec-Sulylbanzene	135968	<	12,500	NO.	5,936	17,000	600	
tert-Buty/benzene	98086	<	12,500	NO	410	410	410	1
Ethylbanzana	100414		250,000	280,000	72,000	280,000	1,100	
leopropythenzene	95626		26,000	J \$7,000	11,450	32,000	500	
p – leopropyttolume	99676	<	12,500	J 21,000	5,963	25,000	600	
n-Propytomzene	103651		62,000	J 80,000	22,390	52,000	440	
Mathyri ethyd katone	78933	<	12,500	NR.	3,525	9,500	625	1
Tokuene	108883		1,300,000	8,000,000	245,754	1,200,000	625	
1,2,3-Trichloropropane	96184		NO	J 24,000	NA	NA	NA.	2
1,2,4 Trimethy/benzene	95636		310,006	420,000	96,533	310,000	2,500	•
1,3,5Trimethylbenzene	108678		120,006	180,000	33,677	120,000	1,000	
o-Xylana	95476		370,000	490,000	97,083	370,000	3,500	
m.p-Xylenee	108383 / 106423		550,000	610,000	167,500	550,000	12,000	
Naphthalare	91203	<	12,500	HA HA	33,432	180,000	140	
•				•			•	
	TCLP Votable On	a i						
	CAS No.		R1-TC-01	- 507-04000 CONTRACTOR (1971)		Madmum Conc	Minimum Cono	Commente
Multysane shlorista	76092	<	50	NA NA	353	950	50	
Benzene	71432		39,000	\$5,000	7,895	39,000	48	
Ethylberzene	100414		3,000	#	709	3,000	50	
Mattyd athyd katone	78933	<	50	櫛	125	520	50	
Toluene	108883		39,000	MA	7,675	39,000	100	
1,2,4—Trimetryfberzene	95636	<	50	MA.	83	150	50	
1,3,5~Trimelhylbenzene	108678	<	50	NR NR	92	300	50	
o-Xylene	95476		4,700	MR.	1,008	4,700	48	
m,p-X ylme	108383 / 106423		13,000	HA.	2,808	18,000	48	
Naphihalene	91203	<	50)	THE STATE OF THE S	75	200	50]	
•	Samivolatile Org.		a — Adathori B	OTOR HORS				
	CAS No.	-12,	R1-TC-01	RI-TC-018	Averens Cond	Maximum Cono	Minimum Cono	Communits
Bis(2-ethylisexyl) phthalate	117017	<	660	NA)	258	560	120	1
DI-n-buylchthelate	84742	č	660	(41)	110	110	110	í
Benzielenin sone	56563		660	MR	2.553	14,000	165	•
Benzo(s)pyrane	50328	<	660	MA	2,553	14,000	165	
Cerbezole	86748	c	1,320	NO	20,400	120,000	92	
Chrysene	218019	<	660	NO	4,220	24,000	165	
Obstracturen	132649	c	660	NA NA	6,536	36,000	72	
Fluoranthene	208440	<	660	NO.	5,887	34,000	165	
Fluorens	56737	<	560	NA NA	21,929	130,000	165	
2,4-Dimetry phenol	105879	J	270	J 1,600	465	630	165	F
2-Methylphanol	95467		6,600	J 2,700	2,543	6,800	165	
3/4—Methylphenol	NA.		4,200		1,951	4,200	105	
Phenoi	108952		8,200	MA	2,976	8,200	165	
Phenenthrene	85018	<	060	NO.	56,909	400,000	165	
Pyrene	129000	<	080	ND.	88,578	530,000	165	
1 – Methylnaphthalene	90120	J	260	NFR.	105,315	630,000	260	
2—Methylnephtheiene	₽1576	å	480	NO.	187,089	1,000,000	165	
2-Mathylchrysene	3351324	<	1,320	鎙	10,107	58,000	330	
Naphthalene	91203	J	1,000	NO NO	42,134	250,000	140	

10E

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Acenephtene	DI-n-buty phthelets	3/4-Methyphenol (total)	1 – Mathyknaphthelene
Big2-ethytenyl phthal	2,4-Dimetry phenol	Phenol	2 – Mathyknaphthelene
Cerbazole	2-Metrychenol	Puome	Naphthelene
		<u>-</u> -	

Masterum Caro 270 270 56 66 13 110 110 1,000 1,0

150,000 120,000 120,000 120,000 170,00

970,000 1, 600,00 1, 600,00 1, 200,00 1,

end 7841 mg/kg | 2400 mg/kg | 2400 mg/kg | 2400 mg/kg | 2500 mg/kg | 2

21, 240, 277 1-TC-018 A 200
R1-TG-01 | 970,000 | 90.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 1

Tota Matata – Mathor 7028 No. 702805 7440305 744030 7440417 7440413 744030 743090 743090 744020 744020 744020 744020 744020 744020 744020 744020 744020

CAS No.	R1-TC-01	RI-10-018	Average Coro	Martine Coro		Commen
7420005	89.00	5	17.8	88		
7440082	90.0	2	1.10	8,		
7440439	90.0	2	9	\$0.50 \$		
74-0702	88	*	52.00	200.00		
7440464	31000	2	55, 15	31000		
7430696			13.80	8 8		
74,29021	Ş		ž	₹		œ
7420905			8	8		
7430087	8.18		17.00	8		
1440020			145.02	31000		
7762492	5	0.48	ž	ž		~
7440022	< 0.25	2	1.20	6.50	0.13	
7440006	v		0.60	2		

Detection lints greater then the highest detected concentration are excluded from the cebulatic Analyse not detected with EPA data, but reported with API data.

Analyte also detected in the associated method blank.
Compound's concentration is estimated. Mass spectral data hidicate the presence of a compot citizate for which the result is less than the laboratory detected.
Not Detected.
Not Applicable.
Not Applicable.

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HYDROREFINING CATALYST

	Volatile Organic	- Method 8260/	L ugkg						
	CAS No.	R5-TC-01	86-TC-018	R79-RC-01	878-AC-018	Average Conc	Meximum Conc	Minimum Cono	Comments
Acatone	87641	NO	NA.	ND	360,000	NA.	NA	NA	2
Benzene	71432	4,200	7,100	100,000	190,000	43,733	\$30,000	4,200	_
n – Butythen zen a	104518	J 890	820	. 650	J \$,000	3,760	10,000	650	
sec-But/benzasa	135988	J 940	1,400	J 510	J 2,400	2,250	5,300	510	
tert-Butylbenzens	38066	ND	540	ND	NR.	NA	NA	NA	2
Ethylbenzane	100414	J 1,200	1 700	23,600	39,000	9,007	23,000	1.200	_
Isopropyberizane	38626	< 625	J 260	1,600	6,900	1,113	1,500	825	1
p-leopropyticiuene	29676	< 625	J 260	< 525	5,300	2.250	5,500	625	
Melhylere chloride	75092	< 625	J 200	< 625	NA	1,383	2,900	625	
Naphthaiene	91203	< 625	NA.	J 960	1 2,900	1,495	2,900	625	
n-Propylbenzene	103651	J 900	1,100	2,000	7,900	1,450	2,000	900	1
Tetrachioroethene	127164	< 525	NP.	< 625	la la	3,583	9,500	625	
Toluene	108883	5,700	8,200	190,000	010,000	69,567	190,000	5,700	
1,2.4 – Trimetty ibenzena	95636	1,900	2,800	6,400	29,000	10,433	23,000	1,900	
1,3,5—Trimethylbenzene	108678	< 625	860	2,600	ia.	3,042	5,900	825	
o Xylene	95476	1,400	2,100	24,000	48.000	10,767	24,000	1,400	
m,p-Xylanes	108383 / 10642	.,	2,800	78,000	140,000	35,033	78,000	4,100	
with American	100000, 100 12	4,,,,,	2200000000000000 00000000000	,,,,	2000 1000 00 00 00 00 00 00 00 00 00 00 0	10,000	0,000	4,100	
		rganics – Method							
	CAS No.	R5-TC-01	88-TC-018		R78-RC018		Maximum Conc	Minimum Conc.	Comments
Acetona	67641	< 50	NA		LA.	70	110	50	
Benzene	71432	110	120	4,200	4,600	1,490	4,200	110	
Ethylbenzene	103414	< 50	NR	140	I	60	140	50	
Methylene chloride	75092	< 50	NA	< 50	NA NA	67	100	50	
Tolusm	108883	< 50	NA	4,000	NA NA	1,367	4,000	50	
1,2,4Trimathylbenzene	95836	< 50	NR	160	IR .	93	180	50	
o-Xylene	95476	< 50	NA	160	in in	83	150	50	
m,p-Xylena	108383 / 10842	< 50	NA NA	530	JA.	210	530	50	
	1								
	Sambonialla Os	nanias — šásšbadi	#9700 unfen						
		ganics - Method		B30_00 01	0 TO . D.C 616	Austran Com	Marianua Cono	Minimum Cons	Comments
Acceptance	CAS No.	RS-TC-01	R5-TC-018		A78-AC-015			Minimum Conc	Comments
Acenaphthene Report & Northea	CAS No. 83329	RS-TC-01 < 165	RSTC018 NR	< 1,850	NP.	268	370	165	1
Benzo(g.h.li perylene	CAS No. 83329 191242	RS-TC-01 < 165 450	R5-TC -019 NR 670	< 1,850 < 1,850	HR. HR.	268 313	370 450	165 165	1
Benzo(g.h.ij pary jene Carbazole	CAS No. 83329 191242 85746	RS-TC-01 < 185 460 NO	RS-TC -018 NR 670 J 150	< 1,650 < 1,650 ND	網 網 網	865 516 AM	370 450 NA	165 165 NA	1 1 2
Benzo(g.h.l) pay lene Carbazole Chiyeene	CAS No. 83329 191242 86746 218019	RS-TC-01 < 165 460 ND ND	RS-TC -b18 MR 670 J 150 J 150	< 1,850 < 1,850 ND ND	帕帕	268 C16 AM AM	370 480 NA NA	185 185 NA NA	1 1 2 2
Benzo(g, h.lj perylene Carbazole Chrysene Diberz(a,h) znihracene	CAS No. 83329 191242 85746 218019 53703	RS-TC-01 < 185 460 ND ND ND	R5-TC-018 MR 670 J 150 J 150 J 170	< 1,850 < 1,850 ND ND ND	照 第 明 明	805 C16 AM AM AM	370 480 NA NA	165 165 NA NA NA	1 1 2
Benzo(g,h.l) perylene Carbazole Chysene Dibenzoluhanikracene Dibenzoluran	CAS No. 83329 191242 85745 218019 53703 132649	RS-TC-01 < 165 460 ND ND ND ND < 165	R5-TC-018 MR 570 J 150 J 150 J 170 NR	< 1,850 < 1,850 ND ND ND ND J 1,100	电影电影	265 C16 AA AA AA 495	370 480 NA NA NA 1,100	165 165 NA NA NA 165	1 1 2 2
Benzo(g,h.ll perylene Carbazole Chrysene Dibenz(s.h) anthracene Dibenzoluran 2,4-Dimethylphanol	CAS No. 83329 191242 86746 218019 53703 102649 105679	RS-TC-01 < 185 460 ND ND ND < 165 < 185	RE-TC-018 MR 670 J 150 J 170 MR NR	< 1,650 < 1,650 ND ND ND ND J 1,100 5,900	· · · · · · · · · · · · · · · · · · ·	208 313 MA NA NA 495 2,152	370 450 NA NA NA 1,100 5,900	165 165 NA NA NA 185 165	1 1 2 2 2
Benzo(g,h.ll perylane Carbazole Chiyeane Dibenz(a.h)anthracane Dibenzoluran 2,4-Dimethylphanol Dimethyl phihalaie	CAS No. 83329 191242 86746 218019 53703 132649 105679	RS-TC-01 < 185 460 ND ND ND < 185 < 165 < 165	AS-TC -018 MR 670 1 150 J 150 J 170 NR NA	< 1,650 < 1,650 ND ND ND ND J 1,100 5,900 < 1,650	, , , , , , , , , , , , , , , , , , , ,	208 313 MA NA NA 495 2,152 208	370 480 NA NA NA 1,100 5,800	185 185 NA NA NA 185 165	1 1 2 2 2 2
Benzo(g, h.l) perylene Carbazole Chrysene Diberz(s,h) anithracene Diberzoluren 2,4 - Dimelhylphenol Dimethyl phihalais DI - n - bulyl phihalais	CAS No. 83329 191242 86746 218019 53703 132049 105079 131113	RS-TC-01 < 185 400 ND ND ND < 185 < 185 < 185 < 185	RS-TC-018 IR 670 1 150 1 150 1 170 NR NR NR	< 1,850 < 1,850 ND ND ND S ND ND ND ND 1,100 5,900 < 1,650 < 1,650		805 313 AM AM NA AM 495 2,152 808	370 480 NA NA NA 1,100 5,900 250 210	165 165 NA NA NA 165 165 165	1 1 2 2 2 2
Benzo(g,h.l) perylane Carbazole Chrysene Dibenzi(sh) enthrecene Dibenzoluran 2,4-Dimethylphenol Dimethyl phihalele DI-n-butyl phihalele 2,4-Dinitrophenol	CAS No. 83329 191242 86746 218019 53703 132649 105679 131113 87742 51265	RS-TC-01 < 165 460 ND ND ND < 165 < 165 < 165 < 165 < 800	#S-TC-018 #B 570 1 180 1 170 170 170 180 170 180 170 180 180 180 180 180 180 180 180 180 18	< 1,850 < 1,850 ND ND ND S J 1,100 6,900 < 1,850 < 1,850 < 8,000		208 313 MA NA NA 495 2,152 208 168 370	370 480 NA NA NA 1,100 5,900 250 210 970	165 105 NA NA NA 165 165 165 165	1 1 2 2 2 2
Benzo(g,h.ll perylane Carbazole Chrysene Dibenzoluran 2,4-Dimethylphenol Dimethyl philiatele DI-n-bulyl phihatele 2,4-Dinitrophenol 2,4-Dinitrophenol	CAS No. 83329 191242 86746 218019 53703 132649 105679 131113 87742 51285 121142	RS-TC-01 < 165 450 ND ND ND < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	日本でであります。 日本では 1570年 1 150年 1 177年 1 1774 1 1	< 1,850 < 1,850 ND ND ND S 1,100 5,900 < 1,850 < 1,850 < 8,000 < 1,650 < 1,650		208 313 NA NA NA 495 2,152 208 188 370 200	370 480 NA NA NA 1,100 5,000 250 210 370 240	165 165 NA NA NA 185 165 165 165 370	1 1 2 2 2 2 1 1 1
Benzo(g, h.ll perylene Carbazole Chrysene Diberzz(a,h) enthracene Diberzz(a,h) enthracene Diberzzoluran 2,4 – Dimethyliphenol Dimethyl phihalais DI – n – bulyl phihalais 2,4 – Dinitrophanot 2,4 – Dinitrophanot Bis(2 – ethylinexyliphihaisie	CAS No. 83329 191242 86746 218019 53703 102649 165679 101113 87742 51285 121142	RS-TC-01 < 185 460 ND ND ND 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185 < 185	# 10 - 中 15 -	< 1,850 < 1,850 ND ND ND S J 1,100 5,900 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850	333333	208 313 NA NA NA 495 2,152 208 188 370 200	370 480 NA NA NA 1,100 5,900 250 210 370 240	165 165 NA NA NA 165 165 165 370 165	1 1 2 2 2 2 2 1 1 1 1 1 1 1 1 1 1
Benzo(g, h.l) perylane Carbazole Chrysene Diberz(s,h) anthracene Diberz(s,h) anthracene Diberzoturan 2,4 - Dimethyliphenol Dimethyl phihalate Di-n - butyl phihalate 2,4 - Dinitrophenol 2,4 - Dinitrophenol Bis (2 - ethyl) hexyliphthalate Fiuoranthene	CAS No. 83329 191242 86748 218019 53703 132049 105079 131113 87742 51285 121142 117617 200440	RS-TC-01 < 165 480 ND ND ND < 165 < 165 < 165 < 165 < 165 < 165 < 165 ND	度5-10-70 (季 原70 670 670 670 180 175 175 175 175 175 175 175 175	< 1,850 < 1,850 ND ND ND ND S 1,100 6,900 < 1,850 < 1,850 < 1,850 < 1,850 ND		268 313 MA NA NA 495 2,152 208 370 200 110 NA	970 460 NA NA NA 1,100 5,900 250 210 970 240 110 NA	165 165 NA NA NA 165 165 165 170 105 370 105 110	1 1 2 2 2 2 1 1 1
Benzo(g,h.l) perylane Carbazole Chrysene Diberz(ah) enthracene Diberzoturan 2,4-Dimethylphenol Dimethyl phihalate 2,4-Dimitrophenol 2,4-Dimitrophenol 2,4-Dimitrophenol 5,6-Dimitrophenol 6,6-Dimitrophenol 7,6-Dimitrophenol 8,6-Dimitrophenol 9,6-Dimitrophenol 9,6-Di	CAS No. 83329 191242 86748 218019 53703 132649 105679 131113 87742 51265 121142 117617 206440 86737	RS-TC-01 < 165 480 ND ND ND < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 1	# 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10	< 1,850 < 1,850 ND ND ND S J 1,100 6,900 < 1,850 < 1,850 < 1,650 < 1,650 < 1,850 ND ND J 2,800	- 8333338	208 313 NA NA NA 495 2,152 208 188 370 110 NA 1,255	970 480 NA NA NA 1,100 5,900 250 210 970 240 110 NA 2,800	165 165 NA NA NA 185 165 165 165 110 110 NA	1 1 2 2 2 2 2 1 1 1 1 1 1 1 2 2
Benzo(g,h.ll perylane Carbazole Chrysene Diberz(a,h) anthracene Diberz(a,h) anthracene Diberz(a,h) anthracene Diberzoluran 2,4 – Dimirophanol 2,4 – Dimirophanol 2,4 – Dimirophanol Bis(2 – ethylhexyl) phthelete Fluorenthere Fluorenthere Indexo(1,2,3 – cd) pyrens	CAS No. 83329 191242 86746 218019 53703 102649 105679 101113 87742 51285 121142 117617 200440 60737	RS-TC-01	##-10 -015	< 1,850 < 1,850 ND ND ND S,900 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 ND ND ND ND ND ND ND ND	2 2833335 383335	268 313 NA NA NA 495 2,152 208 188 370 200 110 NA 1,255 NA	370 480 NA NA 1,100 5,900 250 210 370 240 110 NA 2,800 NA	165 165 NA NA NA 185 165 165 165 165 110 NA	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylene Carbazole Chrysene Diberzz(a,h) anthracene Diberzz(a,h) anthracene Diberzz(a,h) anthracene Diberzz(a,h) anthracene 2,4 – Dimethyl phihalate DI – n – butyl phihalate 2,4 – Dinitrophanot 2,4 – Dinitrophanot Bis(2 – athylhexyl) phihalate Fluorene Fluorene Inderno(1,2,9 – cd;pyrene leophorone	CAS No. 83329 191242 86748 218019 53703 132649 105679 101113 87742 51285 121142 117617 206440 66737 193395 78591	RS-TC-01 < 165 ND ND ND ND ND S 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165 < 165	度5-10-70 年 駅 5 年 5 年 5 年 5 年 5 日 5 日 5 日 5 日 5 日 5 日 5 日 5 日	< 1,850 < 1,850 ND ND ND J 1,100 6,900 < 1,850 < 1,850 < 1,850 < 1,850 J 2,800 ND J 2,800 ND J 1,850		268 313 NA NA NA 495 2,152 208; 370 200; 110 NA 1,255 NA 150;	370 480 NA NA NA 1,100 5,900 250 210 370 240 110 NA 2,800 NA	165 165 NA NA NA 165 165 165 170 165 110 NA 185, NA	1 1 2 2 2 2 2 1 1 1 1 1 1 1 2 2
Benzo(g, h.ll perylane Carbazole Chrysene Diberz(s,h)enthracene Diberz(s,h)enthracene Diberzoturan 2,4 - Dimethyliphenol Dimethyl phihalate Di-n - butyl phihalate 2,4 - Dinitrophenol 2,4 - Dinitrophenol 2,4 - Dinitrophenol Ele (2 - ethylhexyl)phihalate Fluorene Indeno(1,2,3 - cd;pyrene leophorone 2 - Methylchrysene	CAS No. 83329 191242 86748 218019 53703 102649 105679 101113 87742 51285 121142 117617 206440 60737 183395 78591 3351324	RS-TC-01	#	< 1,650 < 1,650 ND ND ND S,900 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 ND	25585555555555555555555555555555555555	208 313 NA NA NA 495 2,152 208 370 200 110 NA 1,255 NA 150 2,343	970 480 NA NA 1,100 5,600 250 210 970 240 110 NA 2,800 NA 150 3,400	165 165 NA NA NA 165 165 165 170 165 110 NA 185 NA 150	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylane Carbazole Chrysene Dibenzoluran 2,4-Dimethylphenol Dimethyl phihalale DI-n-bulyl phihalale DI-n-bulyl phihalale Bis (2-athylhexyl)phihalale Fluorenthere Fluorene Induno (1.2.3-cd)pyrene leophonone 2-Methylchrysene 1-Methylchrysene 1-Methylchrysene 1-Methylchrysene 1-Methylchrysene 1-Methylchrysene	CAS No. 83329 191242 86748 218019 53703 132649 105679 131113 87742 51285 121142 117617 206440 56737 19395 78591 3351324 60120	RS-TC-01	· 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10	< 1,650 < 1,650 ND ND ND 5,900 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 6,000		208 313 NA NA NA 495 2,152 208 168 370 200 110 NA 1,255 NA 1,254 2,343 4,007	370 480 NA NA 1,100 5,900 250 210 970 240 110 NA 2,800 NA 150 3,400 8,600	165 165 NA NA NA 185 165 165 165 110 NA 185 NA 150 330 520	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylene Carbazole Chrysene Diberzz(a,h) enthracene Diberzz(a,h) enthracene Diberzz(a,h) enthracene Diberzz(a,h) enthracene Diberzz(a,h) enthracene 2,4 - Dinitrophanot 2,4 - Dinitrophanot 2,4 - Dinitrophanot Bis(2 - ethylhexyt) phtheiste Fluorene Bis(2 - ethylhexyt) phtheiste Fluorene Indeno(1,2,3 - cd;pyrene leophonone 2 - Methylichysene 1 - Methylichysene 2 - Methylichysene 2 - Methylichysphtheiene 2 - Methylichysphtheiene	CAS No. 83329 191242 86746 218019 53703 102649 105679 101113 87742 51285 121142 117617 200440 86737 193395 76591 3351324 60120	RS-TC-01 < 185	発いで、一切作品の (1988年)	< 1,850 < 1,850 ND ND ND S,900 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 ND 3 2,800 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850		268 313 NA NA NA 495 2,152 208 188 370 200 110 NA 1,255 NA 1,507 2,343 4,007 5,755	370 480 NA NA 1,100 5,900 250 210 970 240 110 NA 2,800 8,600 8,600	165 165 NA NA NA 165 165 165 165 110 NA 165 370 150 330 520	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylene Carbazole Chrysene Diberz(a,h) anitracene Fluorene Inderno(1,2,3-cd),pyrene Isophorone 2-Melhylchrysene 1-Melhylnaphthalene 2-Melhylphaphthalene 2-Melhylphaphthalene	CAS No. 83329 191242 86748 218019 53703 132049 185679 131113 87742 51285 121142 117617 200440 86737 183395 78591 3351324 60120 61576 65457	RS-TC-01		< 1,850 < 1,850 ND ND ND J 1,100 6,900 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850		268 313 NA NA NA 495 2,152 208 370 200 110 NA 1,255 NA 1,507 5,755 2,343	370 480 NA NA NA 1,100 5,900 250 210 370 240 110 NA 2,800 8,600 12,000 5,600	165 165 NA NA NA 165 165 165 170 165 110 NA 165 NA 150 330 520	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylane Carbazole Chrysene Diberz(s,h)enthracene Diberz(s,h)enthracene Diberzoturan 2,4 - Dimethylphenol Dimethyl phihalate Di	CAS No. 83329 191242 86748 218019 53703 132649 105679 131113 87742 51285 121142 117817 206440 86737 193395 78501 3351324 60120 61579 65487 NA	RS-TC-01	经	< 1,850 < 1,850 ND ND ND 5 1,100 6,900 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 < 1,850 1,850 ND 3 2,800 ND 3 8,600 12,000 5,600 J 1,600		208 313 NA NA NA 1,52 2,152 208 188 370 110 NA 1,255 1,007 5,755 2,008	370 480 NA NA 1,100 5,900 250 210 370 240 110 NA 2,800 8,600 12,000 5,600 1,800	165 165 NA NA NA 185 165 165 110 NA 155 NA 150 330 520 165	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylame Carbazole Chiyeere Diberz(a,h) anthracene Bis (2-ethylhexyl) phtheiste Fluorenthere Fluorene Indeno(12.3-cd)pyrene leophonone 2-Methylchrysene 1-Methylchrysene 2-Methylphenol 3/4-Methylphenol Naphtheisne	CAS No. 83329 191242 86748 218019 53703 132649 105679 131113 87742 51285 121142 117617 206440 86737 19395 78591 3351324 60120 91578 95487 NA	RS-TC-01	# 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10	< 1,850 < 1,850 ND ND ND 5,900 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,850 ND 3 2,800 ND < 1,850 < 1,850 < 1,850 < 1,850 J 3,000 6,800 12,000 5,600 J 3,000 J 3,000		268 313 NA NA NA 495 2,152 208 168 370 200 110 NA 1,255 NA 1,555 2,403 4,007 5,755 2,008	370 480 NA NA 1,100 5,900 250 210 970 240 110 NA 150 3,400 6,800 12,000 5,600 1,800 3,000	165 165 NA NA NA 185 165 165 165 110 NA 150 330 520 155 165	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylane Carbazole Chrysere Diberz(a,h) enthracene Diberz(a,h) enthracene Diberz(a,h) enthracene Diberzoluran 2,4 – Dimethyliphanol Dimethyl phthalate DI – n – bulyl phthalate 2,4 – Dimitrophanot 2,4 – Dimitrophanot Bis (2 – ethylhexyl) phthalate Fluorene Indemo(12.3 – cd) pyrene leophorone 2 – Methylichysene 1 – Methylichysene 1 – Methyliphaphthalane 2 – Methyliphaphthalane 2 – Methyliphaphthalane Phenanthane Phenanthane	CAS No. 83329 191242 86748 218019 53703 132049 105679 105173 87742 51285 121142 117617 206440 56737 193395 76591 3351324 60120 61576 65457 NA 61203 85018	RS-TC-01	日本でである。 のでは、日本では、日本では、日本では、日本では、日本では、日本では、日本では、日本	< 1,850 < 1,850 ND ND ND J 1,100 5,900 < 1,850 < 1,850 < 1,850 ND J 2,800 < 1,850 < 1,650 < 1,650 < 1,650 J 2,800 J 1,650 J 3,300 J 1,800 J 3,000 J 2,200 J 2,200 J 2,200	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	268 313 NA NA NA 495 2,152 208 168 370 200 110 NA 1,255 NA 150 2,343 4,007 5,755 2,008 712 1,245 1,168	370 480 NA NA 1,100 5,900 250 210 970 240 110 NA 2,800 8,600 12,000 5,600 1,800 2,200	165 165 NA NA NA 145 165 165 165 170 185 110 NA 150 330 520 155 165	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylane Carbazole Chrysene Diberz(a,h)anitracene Diberz(a,h)anitracene Diberz(a,h)anitracene Diberz(a,h)anitracene Diberz(a,h)anitracene 2,4 - Dimitrophanol 2,5 - Striphinesyi)phthaiste Fluorene Indenol (1,2,3 - cd)pyrene Isophonone 2 - Melhylchysene 1 - Melhylchysene 1 - Melhylchysene 2 - Melhylchphanol 3/4 - Melhylphanol Naphthaine Phenol	CAS No. 83329 191242 86748 218019 53703 132649 165679 131113 87742 51285 121142 117817 206440 86737 183395 78591 3351324 60120 61570 95487 NA 61203 85018 106952	RS-TC-01		< 1,650 < 1,650 ND ND ND J 1,100 6,900 < 1,650 < 1,650 < 1,650 < 1,650 ND J 2,800 ND J 2,800 12,000 12,000 J 1,600 J 2,200 J 1,600	288 288 28 28 28 28 28 38 38 38 38 38 38 38 38 38 38 38 38 38	268 313 NA NA NA 495 2,152 208 188 370 100 NA 1,255 NA 1,255 2,403 2,343 4,007 5,755 2,008 712 1,245 1,165 710	370 480 NA NA 1,100 5,000 250 210 370 240 110 NA 2,800 NA 1,50 3,400 6,600 12,000 5,600 1,800 3,000	165 165 NA NA NA 165 165 105 110 NA 185 NA 150 330 520 165 165	1 1 2 2 2 1 1 1 1 1 1 2 2 2
Benzo(g, h.ll perylane Carbazole Chrysere Diberz(a,h) enthracene Diberz(a,h) enthracene Diberz(a,h) enthracene Diberzoluran 2,4 – Dimethyliphanol Dimethyl phthalate DI – n – bulyl phthalate 2,4 – Dimitrophanot 2,4 – Dimitrophanot Bis (2 – ethylhexyl) phthalate Fluorene Indemo(12.3 – cd) pyrene leophorone 2 – Methylichysene 1 – Methylichysene 1 – Methyliphaphthalane 2 – Methyliphaphthalane 2 – Methyliphaphthalane Phenanthane Phenanthane	CAS No. 83329 191242 86748 218019 53703 132049 105679 105173 87742 51285 121142 117617 206440 56737 193395 76591 3351324 60120 61576 65457 NA 61203 85018	RS-TC-01	日本では、100mの 100mの	< 1,650 < 1,650 ND ND ND J 1,100 5,900 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 < 1,650 J 2,200 J 6,600 J 1,800 J 2,200 J 1,800	288 288 28 28 28 28 28 38 38 38 38 38 38 38 38 38 38 38 38 38	268 313 NA NA NA 495 2,152 208 168 370 200 110 NA 1,255 NA 150 2,343 4,007 5,755 2,008 712 1,245 1,168	370 480 NA NA 1,100 5,900 250 210 370 240 110 NA 2,800 8,600 12,000 5,600 1,800 3,000 2,200 1,800 3,300	165 165 NA NA NA 145 165 165 165 170 185 110 NA 150 330 520 155 165	1 1 2 2 2 1 1 1 1 1 1 2 2 2

HYDROREFINING CATALYST

TCLP Serrivolatile Organics — Methods 1311 and 82708 pg/L R78—RC-01 R78—
Bis Carbazole 117817 3,100 NR < 50 NR 1,056 3,100 18 1 1 1 1 1 1 1 1
Carbazola 80748 100 NR 17 17 17 17 17 17 17
2,4-Dimethylphenol 105679 50 54 220 54 100 220 30 1 1 1 1 1 1 1 1 1
Dimethylphthalates
1Methylnaphthalens
2-Methylnaphthelene 91576 < 50 NR < 50 NR 173 420 50 24 NR 173 420 50 374 Methylphanol (total) NA < 50 ND 2200 148 137 200 50 374 Methylphanol (total) NA < 50 ND 150 88 88 150 50 NR 170 50 NR 180 170 50 NR 180 170 50 NR 180 170 180 180 180 180 180 180 180 180 180 18
2-Methylphenol (Iolal) 3/4-Methylphenol (Iolal) NA < 50 ND 150 86 86 150 50 ND 170 50 NB 150 86 86 150 50 NB 150 N
NA S0 ND 150 88 88 150 50 NB NB NB NB NB NB NB N
Naphthalene
Phenol 108952 JB 17
Total Metals - Methods 6010, 7060, 7421, 7470, 7471, and 7841 mg/kg CAS No. R5-TC-01 R6-TC-01 R78-RC-01
CAS No. R5-TC-01 R6-TC-018 R78-RC-018 R78-RC-018 Average Conc Maximum Conc Comments
Aluminum Animony Animony Arsenia Arsen
Aluminum Animony Animony Arsenia Arsen
Arsenio 7440362 100.0 96.5 850.0 NF 493.3 730.0 100.0 8eryllum 7440417 43.0 26.6 < 0.5 NR 15.3 43.0 0.5 Cadmium 7440439 8.7 NR 6.2 24.0 15.5 8.7 2.5 Chromium 7440473 33.0 28 6.7 NR 14.9 33.0 5.0 Cobell 7440484 18,000.0 18,200 8,700.0 21,800 18,000.0 24,000.0 8,700.0 Copper 7440508 46.0 NR 17.0 23.6 31.7 46.0 17.0 Inon 7440508 730.0 NR 470.0 NR 706.7 1,00.0 470.0 Lead 7439021 1.3 NR < 0.3 NR 1.5 2.0 0.3
Arsenio 7440362 100.0 96.5 850.0 NF 493.3 730.0 100.0 Beryllium 744017 43.0 96.5 850.0 NF 15.3 43.0 0.5 85.0 10.0 10.0 10.0 10.0 10.0 10.0 10.0 1
Beryllium 7440417 43.0 26.6 < 0.5 NR 15.3 43.0 0.5 Cadmium 7440439 8.7 NR 5.2 24.0 5.5 8.7 2.5 Chromium 33.0 28 6.7 NR 14.9 33.0 5.0 Cobell 7440484 18,000.0 18,200 8,700.0 21,900 18,900.0 24,000.0 8,700.0 Copper 7440506 46.0 NR 17.0 23.6 31.7 40.0 17.0 Iron 745908 730.0 NR 470.0 NR 706.7 1,100.0 470.0 Lead 7459021 1.3 NR < 0.3 NR 1.5 2.0 0.3
Cadmium 7440439 8.7 NR 5.2 24.0 5.5 8.7 2.5 Chromium 7440473 33.0 28 6.7 NR 14.9 33.0 5.0 Coball 7440484 18,000.0 18,200 8,700.0 21,800 18,000.0 24,000.0 24,000.0 24,000.0 6,700.0 Copper 7440508 48.0 NR 17.0 23.6 31.7 46.0 17.0 Ion 7439921 730.0 NR 470.0 NR 760.7 1,90.0 470.0 Lead 7439921 1.3 NR < 0.3
Chromium 7440473 33.0 26 6.7 NF 14.9 33.0 5.0 Coball 7440484 14,000.0 18,200 8,700.0 21,800 16,900.0 24,000.0 24,000.0 27,00.0 Copper 7440508 48.0 NR 17.0 23.6 31.7 46.0 17.0 Iron 745998 730.0 NR 470.0 NR 766.7 1,100.0 470.0 Lead 7439921 1.3 NR 0.3 NR 1.5 2.0 0.3
Coball 7440484 18,000.0 18,200 8,700.0 21,900 18,900.0 24,000.0 4,700.0 8,700.0 21,900 18,900.0 24,000.0 4,700.0 17.0
Copper 7440508 45.0 NR 17.0 23.6 31.7 46.0 17.0 Iron 7439998 730.0 NR 470.0 NR 766.7 1,100.0 470.0 Lead 7439921 1.3 NR 0.3 NR 1.5 2.6 0.3
Iron 7436986 730.0 NR 470.0 NR 786.7 1,100.0 470.0 Lead 1.3 NR < 0.3 NR 1.5 2.6 0.3
Lead 7439921 1.3 NA < 0.3 NA 1.5 2.8 0.3
Manganees 7439965 ND ND 10.7 NA NA NA 2
Motybdanum 7439987 74,000.0 86,800 25,000.0 52,900 58,600,7 77,000.0 25,000.0
Nickel 7440020 14,000.0 21,400 < 8.0 65 4,952.7 14,000.0 8.0
Selenium 7762492 7.8 ND 1.9 NF 21.2 54.0 1.9
Thaillum 7440280 < 1.0 NR < 1.0 NR 1.5 2.0 1.0
Vanadium 7440922 31,000.0 40,800 190.0 376 10,385.0 31,000.0 25,0
Zho 7440866 ND 49.5 ND 25.4 NA NA NA 2
TCLP Metals - Methods 1311, 6010, 7083, 7421, 7470, 7471, and 7841 mg/L
CAS No. R5-TC-01 R5-TC-01 R75-RC-01 R75-RC-018 Average Conc Maximum Conc Comments
Aluminum 7429905 4.40 NR < 1.00 NR 2.13 4.40 1.00
Antimony 744(260 < 0.50 NR 9.60 16.6 3.40 9.60 0.30
Arsento 7440382 0,23 9,25 34,60 20.1 13,71 34,00 0,23
Barium 7440393 ND 0,23 ND 0,07 NA NA 1A 2
Cadmium 7440439 ND NR ND 0,27 NA NA NA 2
Cobalt 7440484 55.00 NR 180.00 NR 135.00 100.00 55.00
Iron 7435696 3.90 NR 6.20 NR 9.50 19.00 3.30
Lead 7439921 ND ND 1.6 NA NA NA 2
Manganses 7439965 0.17 NR 0.18 0.29 0.08
Molybdanum 7439987 < 1,00 NR 13,00 NR 10,33 17,00 1,00
Nickei 7440020 87.00 NR 0.73 NR 28.24 67.00 0.73
Vanedium 7440822 3.30 NR < 0.25 NR 1.27 3.30 0.25
Zino 7440666 0.39 NR < 0.10 NR 0.20 0.29 0.10

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyte not detected with EPA data, but reported with API data.

- Analyte also datected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory dataction limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.
- NR. Not Reported, or concentration below the method detection limit.

SCOT CATALYST from SULFUR COMPLEX

	Volatile Organice	- Nethod 8260	A μg/kg				
	CAS No.	R7B-SC-01	R78-8C-018	Average Conc	Maximum Conc	Minimum Cone	Comments
Benzene	71432	< 625		33	60	5	1
n Butylbenzen e	104518	J 700	NR.	243	700	5	
Trichloroffuora methane	75894	< 625	NR	27	20	25	1
Toluene	108883	< 625	J 360	15	24	5	1
1;2,4 - Trimethylbenzene	95636	7,500	590	2,510	7,500	5	
1,3,5 – Trimethylbenzene	108678	3,300	J 590	1,117	3,300	5	
o — Xylene	95476	J 1,040	J 230	356	1,040	5	
m,p-Xy lenes	108383 / 1064 23	2,500	J 260	856	2,500	5	
4 – Methyl – 2 – pentanone	108101		NR.	126	250	5	1
Methyl ethyl ketone	78933	< 625	NR	233	460	5	1
Methylene chloride	75092	< 625	J 110	33	60	5	1
Mathylane chlorida		R78-SC-01 < 50	NR NR	Average Conc	Maximum Conc 1,800	Minimum Cone 50	Commente
	CAS No.	R7B-SC-01		Average Conc	Medmum Conc	Minimum Conc	Comments
Bis(2-ethylhexyl) phthalain	117817	J 68	NR.	184		88	
Butyl benzyl phthalete	85087	ND		NA	NA.	NA	2
Di-n-butyl phtheiste	84742	J 120	NA	110	120	90	
Pyridine	110881	NO	J 140	NA	NA	NA	2
Bis (2—ethyihexyi)phtheleis Di—n—butyi phtheleis Pyridine	TCLP Semivolatil CAS No. 117817 84742 110881	R7B-SC-01 < 50	NR NA		Maximum Conc 540 31 240	Minimum Conc 35 31 100	Commenta 1

SCOT CATALYST from SULFUR COMPLEX

	Total Metals - M CAS No.		30, 7421, 7470, 74		_	40.1	
Aluminum	7429905	360,000	R7B-SC-01S 252,000	223,333.3		Minimum Cone	Comments
	7440360		202,000 NR	,	360,000.0	110,000.0	
Antimony	1	20.0	nn NR	13.3	20.0	0.0	
Areenic	7440382	1	500000000000000000000000000000000000000	19.3	28.0	10.0	
Beryllium	7440417	2.0	NO	1.3	2.0	0.5	
Cadmium	7440439	9.4	NR NR	7.2	0.4	5.7	
Chromium	7440473	13.0	NA	8.0	13.0	4.8	
Coball	7440484	19,000.0	19,700	14,333.3	19,000.0	11,000.0	
Copper	7440508	33,0	21.6	25.3	33.0	14.0	
tron	7439898	3,500.0	NR	1,810.0	3,500.0	230.0	
Mangantes	7439965	54.0	50.6	19.5	54.0	1.5	
Molyb denu m	7439987	54,000.0	63,700	42,333.3	54,000.0	25,000.0	
Nickel	7440020	73.0	48.2	70.3	120.0	18.0	
Selenium	7782492	< 2.5	NA NA	1.4	2.2	0.5	1
Sodium	7440235	< 500.0	NR NR	1,433.3	2,500.0	500.0	
Vanadium	7440822	210.0	319	180.7	260.0	72.0	
Zinc	7410666	ND	36.8	NA	NA.	NA	2
	TCLP Metale - #	Wethode 1311, 60	10, 7060, 7421, 74	170, 7471, and 7	841 ma/L		
	CAS No.	R7B-SC-01	R78-BC-018			Minimum Conc	Comments
Aluminum	7420905	32.00	NR.	23.67	32.00	17.00	
Arsenic	7440382	ND	0.61	NA	NA	NA	2
Cadmium	7440439	0.20	0.045	0.08	0.20	0.03	
Chromium	7440473	0.13	NR	0.08	0.13	0.05	
Cobalt	7440484	450.00	NR	248.67	460.00	66.00	
Iron	7439890	< 0.50	NA	2.43	6.30	0.50	
Lead	7439921	ND	3.5	NA	NA	NA	2
Manganese	7439965	0.98	NA	0.47	0.99	0.08	
Molybdanum	7439987	480.00	NA	316.33	480.00	39.00	
Nickel	7440020	0.54	NR	0.44	0.58	0.20	
Selentum	7782492	NO	1.1	NA.	NA.	NA	2
Venedium	7440622	i i	NR	1.18	1.90	0.25	-
f =17=47=11	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		MAY COURSE OF DOOR AND IN		,	J.13	

Commenta:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyte not detected with EPA data, but reported with API data.

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is tess than the isboratory detection limit, but greater than zero.
- NO Not Detected.
- NA Not Applicable.
- NR Not Reported, or concentration below the method detection limit.

	Volette Organice -	- Method 82604 µg/kg	Approx.	919	1.4		•		
and the same	- CAS HE.	10127 VE		10-E3-9/E		Average Conc. M	Medmum Cond	Minimum Cono	Comments
Actions	1000	2	9		8	₹	₹	¥	es.
Benzere	71432	¥ 782	024		8	7,092	26,000	52	
n – Bulythanzana	104518	<u>52</u>	\$		±	1,032	57,000	22	
eac - Butylbanzana	135086	- 152 - 152 - 152	5	10	Ę	4,284	23,000	22	
Eftylbensene	414001	52	2		200	13,262	51,000	52	
2-Heumone	59:786	<u>88</u>	E	v	2	3,054	23,000	55	
leopropylbenzene	928826	25	\$	150	Ę	5,494	27,000	25	
n-Propytbenzene	103651	- N	9	570		10.222	90,000	52	
Tokuene	100003	25	8	1,000		11.780	37,000	52	
1,2,4 -Trimethylbenzene	95636	2.800	٨	4,000		50.700	310,000	25	
1.9.5 - Trimedivibenzene	108078	560		200		18.726	000	90	
O-Malana	92750			9		20, 10	80000	2 6	
	Constant Calcado	- 6		3 3	3	3	DOTTO	Q :	
m.p	106543 / 106423	220	7	000	8	42,124	170,000	52	
Methyl effyl Ketone	76633		5	200	E	\$	3200	52	
Methylers chlorids	15002	, 2	5	V 75	½	8	92	22	
Naphtrala na	6839	1,900	<u>8</u>	064	2	2,064	8,500	22	
	TO: O Material Co.	4.4	;	-					
		INCS - MENIOR			-	,	•		
	day and	10-12-71 10-12-71		5122		Werings Cond M	BARMUM Cone	Minimum Conc	Comment
	1.432	3	2	2		2	000,6	₹	
ETHYDentern	700	Ž.	5	8		Ξ	470	9	
Tokuene	105863	۸ <u>چ</u>	5	7		1,010	4,000	20	
Trickloroethene	76016	2	⊋	ğ		≨	₹	¥	~
1,2,4 - Trimethylbenzens	95636	- -	F	\$		242	610	20	
1,3,5—Trimethytbenzene	100670	80	Ę	3		2	160	20	
o-Xybane	05470	Š	Ş	210		330	1,200	8	
A.p.—Xytens	108363/106423	2	€	2	5	88	1,500	20	
Methylene chloride	75002	50	\$	200		250	930	99	
Maphibalana	P1203	120	SE SE	22		44	52	09	
	Seminolatic Organica	1 6	Melhod 62/05 yg/kg	0,00	Second Second				
Antheorem	Temps.	10-10-10-10-10-10-10-10-10-10-10-10-10-1	2 9 2	10101010		TANK TO THE PARTY OF THE PARTY	Later municipal		
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Burha hanny philippin		2				9 9			
N. v. brita philadet	41.40	200		2 :			7 9	6	-
	77.70	000	C .	2 :	E S	9 6	063	,	-
Bearoft or software finds	***	200	. .		2 \$	2 6	900	60.	
Internation Broadens	C7 C7 C7	200	3 6	9 3	2	200	200	6	
	757.61	20,0		2	2 :	200	0000	20	
	20350	2,900	\$	£ :	2	203	2,000	165	
Dependig hjendi econo	53703	790	5 .	- 282	Ē	2	200	185	
2,4 - Okrashyphenoi	105079	105	2	* \$	E	2,638	15,000	165	
Chrysens	2,901	000	000	· •	2	49	000	105	
Fluoranthene	200440	6,000	8	× 55	2	2,053	9,000	105	
Fluorene	00737	405	E	v	Ξ	E	78	92	·r
moerco 1,2,2 - cappinere	90000	90		₽ ;	Ž	700	4.600	103	
Stock of the stock		SD.			3 !	707	000	165	p
1 - Metanymetanumena	100	000.	5 (۷.	Ε :	B (0)	9	930	
2 - Memymephinesene	0.4570	000'6	00	,	2	0,020,0	86.	ā ;	
2 - Methylphenol	28+50	165	5	22	Ξ	7	25,000	165	
3/4 - Methylphenol (total)	₹	105	5		%	4.084	24,000	165	
Nephthelene	01203	2,100	2,800	2	2	7 30'6'	000'8	130	
Phenenthrene	82018	1,000	00 di	v	2	2,040	000	9	
Phenol	108652	4 105	E	· •	¥	20,4	21,000	105	
Pyrene	128000	4,200	00. *	* 55	2	850	4,200	105	
2 - Mathytchrysene	3351324	J 370	₹	···	5	336	370	330	

REFORMING CATALYST

	TCLP Semivolation	· Organion - Mai	hode 1911 and 8	1270D8					
	CAS No.	R2-CR-01	R2-CR-018		979 CG 019	Augman Cons	Medmum Conc	Minimum	
Bis(2 - ethylhexyl) phthalete	1	< 50	NA NA	< 50	NA	52	81	Minimum Cone	Comments
DI+n-but phticists	84742	< 50	NA.	< 50	NR NR	48	48	50	
2,4 Dimethylphenol	105879	< 50	NA.	< 50	NR.	115		48	1
t - Meihykaphthalene		J 34	NA NA	< 100	NR NR	25	480	50	
2-Methylaphthelene	[J 43	187	< 50	NR.	23 43	34	18	1
2-Methylphenol	95487	< 50	NA NA	× 50	NR.	43 145	43 620	43	1
	NA NA	< 50	NA NA	< 50	NR.		. 1	50	
3/4 - Methylphenol (total)	91203	J 59	NET	3	200000000000000000000000000000000000000	123	490	50	
Naphthalene	1	•	12/90/2007/09/5/5/5/5/5	< 50	NR	46	59	27	
Phenanthrane	85016	J 35	NFI.	< 50	NR	35	35	35	1
Phenoi	108952	< 50	MI	< 50	NR	105	380	50	
	Total Metals - Me	stheds 6010, 706	0, 7421, 7479,74	171, and 7841 mg					
	1 .	R2-CR-01	R2-CR-018		R7B-CR-018	Average Conc	Maximum Cono	Minimum Conc	Comments
Aluminum	7429905	230,000.0	47.300	460,000.0	242,000	250,000	460,000	150,000	
Antimony	7440360	< 12.0	NA.	< 6.0	NA NA	8.6	17.0	6.0	
Amenic	7440382	< 10.0	1	< 20.0	ND	19.3	45.0	10.0	
Barlum	7440393	NO	1.0	ND	ND	NA.	NA	NA	2
Chromium	7440473	44.0	22.0	25.0	33.8	126.5	550,0	25.0	
Coball	7440484	< 10.0	ND	< 5.0	26,6	468.3	2,900,0	5.0	
Copper	7440508	< 6.0	7.0	26.0	ND	1,374.8	8,100.0	2.5	
tron	7439896	460.0	NA	21,000.0	NR	13,080.0	51,000.0	120.0	
Lacd	7439921	< 3.0	124	< 0.6	1.6	27.7	180.0	0.3	
Menganese	7439965	< 3.0	73	43.0	35.7	43.7	180.0	1.5	
Molybdenum	7439987	< 13.0	184	18.0	73.6	1,678.8	10,000.0	0.5	
Nickel	7440020	< 8.0	NF1	12.0	NA	73.7	220.0	4.0	
Selentum	7782492	< 5.0	NA.	< 2.5	NA	4.2	14.0	0.5	
Sodium	7440235	< 1,000.0	NA.	< 500.0	NR	2,166.7	10,000.0	500.0	
Venedium	7440822	< 10.0	ND	< 25.0	17.4	21.0	78.0	5.0	
Zina	7440666	< 4.0	NA		NR	456.3	2,900.0	2.0	
	TCLP Metals - M	ethods 1311,601	IO 7040 7491 7	470 7471 and T	341 mod				
	CAS No.	P2-CR-01	R2-CR-018	A7B-CR-01		Average Como	Madmum Cono	Minimum Conc	Comments
Alumiqum	7429905	28.00	NA	350.00	NA.	141.72	360.00	5.3	COUNTRIDE
Animony	7440360	NO.	NA.	ND	0.17	NA	NA.	NA NA	2
Amenio	7440362	NO.	0.13	ND	ND.	NA NA	NA NA	NA NA	2
Barkim	7440393	ND.	0.081	ND	0.37	NA.	NA NA	NA.	2
Cadmium	7440439	NO	ND.	ND	0.1	NA.	NA.	NA NA	2
Chromium	7440473	< 0.05	0.051	0.19	0.2	0.10	0.23	3.05	2
Coball	7440484	< 0.25	NA.	< 0.25	NR	18.04	95.80	3.05	
	7440508	< 0.23	MA	< 0.23	NA NA	10.30	61.00		
Copper	1	1	000000000000000000000000000000000000000	1	2000 000 000 000 000 000 000 000 000 00			0.13	
lron Lond	7439896	< 0.50	M	00.8	NR.	2.35	8.90	3.50	
Lead		< 0.02	ND	1.10	0.78	0.48	1.70	3.02	
Manganera	7430985	< 0.08	NA	1.60	NR	0.63	\$. P 0	3.D8	
Nickel	7440020	< 0.20	NA	0.65	NR	0.93	3.60	05.0	
Selentum	7752492	< 0.03	NA	< 0.03	NR	0.03	0.06	3.03	
Zino	7440666	0.61	NA)	< 0.10	NR	16.70	99.00	3.10	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations
- 2 Analyte not detected with EPA data, but reported with API data.

Notes

- B Analyte also detected in the essociated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate he presence of a compound that meets the identification criteria for which the result is less than the laboratory detection timit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.
- NR Not Reported, or concentration below the method detection limit.

SLUDGE from SULFURIC ACID ALKYLATION

Acetone
Ethylbenzene
Toluene
1,2,4-Trimethylbenzene
m,p-Xylenes
Naphthalene

Acetone Methylene chloride Methyl ethyl ketone

Bis(2-ethylhexyl)phthalate Di-n-butyl phthalate 7,12-Dimethylberz(a)anthracene Benz(a) anthracene Benzo(g,h,i)perylene Benzo(a)pyrene Chrysene Flucranthene Flucrene Phenanthrene Pyrene 1 - Methylnaphthalene 2-Methylnaphthalene 2-Methylchrysene Naphthalene N-Nitrosodiphenylamine

1 -- Methylnaphthalene 2 -- Methylnaphthalene Naphthalene

Volatile Organics -		
	R8B-SS-01	R88-SS-018
67641	7,000	2,300
100414 J	150	< 250
108883 J	160	< 250
95636 J	280	J 180
108383 / 106423 J	170	< 250
91203 J	180	< 250

TCLP Volatile Orga	nics — Methods	1311 and 8260A μg/L
CAS No.	R8B-SS-01	R8B88018
67641	810	NA
75092 B	200	NR
78933	120	54

Semivolatile Organ	nics – Method 8	32708 μg/kg
	R88-89-01	
117817	1,000	1,300
84742 J	250	< 550
57976	ND	J 300
56553 J	270	J 220
191242 J	250	J 140
50328 J	190	< 850
218019 J	460	J 420
206440	ND	J 230
86737 J	210	J 390
85018 J	680	1,300
129000	2,200	1,800
90120 J	1,400	2,700
91576	2,200	5,300
3351324 J	340	NR
91203 J	290	J 830
86306	ND	J 940

TCLP Semivolatile Organics - Methods 1311 and 8270B µg/L CAS No. R8B-SS-01 R8B-SS-01S 90120 J 24 NR 91576 J 31 NR 91203 J 30 NR

SLUDGE from SULFURIC ACID ALKYLATION

Total Metals —	Methods 6011	0. 7060. 7421	. 7470. 7471.	and 7841 mg/kg

-01 R8B-SS-019
THE THE TOTAL OF
,100 1,390
5.6 8,1
2.4 2.8
3.2 141
0.09 < 0.25
,000 NR
190 238
3.3 4.0
37.0 68.0
0.00 NR
23.0 53,7
670 NR
45.0 55.1
.035 0.16
1.7 3.1
280 359
200 NR
.000 NR
3.4 3.9
58.0 54,1

TCLP Metals - Methods 1311, 6010, 7060, 7421, 7470, 7471, and 7841 mg/L

CAS No.	R8B-\$\$-01	R88-88-018
7429905	87.0	NR
7440360	ND	0.29
7440393	ND	0.11
7440439	430.0	NR
7440473	15.0	28,4
7440508	1.4	NR
7439898	520.0	NA
7439921	1.1	0.71
7439954	56.0	NA
7439965	3.7	NR
7440020	17.0	NR
7440666	4.0	NA

Copper iron Lead Magnesium Manganese

Nickel Zinc

Aluminum Antimony Berium Calcium Chromium

Aluminum Antimony Arsenic **Barium** Cadmium Calcium Chromium Cobalt Copper tron Lead Magnesium Manganese Mercury Moylbdenum Nickel Potassium Sodlum Vanadlum Zinc

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NR Not Reported.

HF ALKMATION SLUDGE

	Volatila Organica - Method 82604 µg/kg	- Method 8260	M. ug/kg						
	CAB No.	R3-HS-01	83-HS-018	R0-H8-01	R0-H8-018	Average Coro	Meximum Conc	Minimum Cone	Comment
Асетопе	97641	v		16.	8,	6 1.0	16,000	2,600	
Benzans	7432	_	7	v	2	986,4	¥ 000	313	
Chlorobenzene	108907	× 12,500	2	\$25 \$	Ξ	5	009	919	-
n-Butylbenzene	104518	< 12,500	31,000	*	7,800	627	9	313	-
Crotorvalderly-de	4170003	95,000		٧	Ŧ	10.043	62,000	913	
eno-Buyksentane	135968	7 20,000	2	٧	2,400	A.4.	20.000	200	
tart - Butylbenzene	99060	× 12,500	5	٧	5	25	98	22	~
frama - 1,3 - Dichloropropera	10061026	3		2	80.03	ž	¥	₹	N
Ethylbenzone	100414	73,000		\$250 V	8 83	15,072	73,000	320	
Bopropylbenzene	92929	14,000	7	200	- S84	3.243	14,000	313	
p-(soproppidationens	90670	13,000		v	2	3.00	13,000	313	
Methylane chibrida	75002	9	- -		2	42	4	7	•
Method affine kentome	78833	7		9.60	3	-			J ~
n-Procedbenzene	103051	ı	4	·	864	13 A.D	2 000	7	•
Tokkene	10883	\$5,000			800	7.45		, <u>e</u>	
\$ 2.4~ Trimelindbentens	95536	464.000		5	8	101,145	98	7.5	
1.3.5. Tilmailteineozene	104678	143.000			800	30.465	OUU 571	404	
O-Yukana	05578	127,000				, K	27 000		
St. D. Mylanes	106363/106423	352,000				71.507	352.000	997	
Naphthalene	61203	37,000			8	1908	37,000	313	
	TOLP Volatile Ore	venice - Metho	TOLP Volatile Organics - Nethods 1311 and 8280A was	way					
	CASNO	R3-H8-01	H3-48-018	RO-H8-0\$	R9-H8-018	Average Coro	Average Code Maximum Cone	Minimum Cone	Comments
Acetone	67641	33		1.280	½	542	1,280	98	
Benzene	71432	380	8	28	2	20	35	8	
Ethylberzens	10041	9 530	2	3	5	\$	230	8	
n-Propyibenzene	103651	8		8	2	2	52	8	
Toluene	106683	1,200		× 28	2	580	087	8	
Methylana chlorida	75002	28		25	7	975	2,000	8	
Methyl ethyl ketone	78833	S		5 8	₹	2	<u>5</u>	S	
1,2,4-Trimeflythenzene	92930	000		3	5	98	300	8	
1,3,5-Trimethylbenzene	100678	9	2	3	£	280	1,100	8	
0-Xylens	95476	_		٧	5	28	1,100	8	
m.pXylens	108383 / 106423	9	9	8	5	2	9	8	
Maphinelene	91203	\$	E	28	E	127	8	8	
	Goodkealeric Direction - Mathematical College	nice - Mathewal	SOUTH COMPA						
		DOLENN - SONA	DECEMBER OF THE PARTY	91					
Becommethic	TOWESS.		u	- CZ	1	AMA SERVICES	MAKITEUM COTO	MANA CONC.	Continents Continents
Bla (2- efficiently and braining to	117617	2,100		A 157	98 000	1,342	2.100	50	- ۱
Fluorene	20037	2900		× 5.57	2	555	2.800	12	
Indene	86.38	3300	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	5,157	2	3	0000	13	
Phenenthene	85018	2,500		< 5,157	2	2,401	7,500	1,000	,
Phenol	100052	120,000	М	٧	2	25,677	120,000	<u> </u>	
1 - Methylnaphthalens	80130	000 86		v	2	8	0000'98	2,000	
2-Methylnaphthelene	0/310	180,000		v	15,000	8	160,000	1,000	
2-Methylphenol	05487	16,000		٧	2	4,677	16,000	\$	
3/4 ~ Methylphanol (total)	≨	000 7		٧	2	7,0,0	32,000	105	
Naphthalene		110,000		7,000	2	23,073	110,000	1,000,	

HF AUGYLATION SLUDGE

	TCI P Samhydati	io Organica — Mo	ithods 1311 and 827	ne uali					
	CAS No.	R3-H8-01	A3-HS-018	R9-H8-01	R9-H8-018	Average Coro	Maximum Conc	Minimum Cone	Comment
Bis(2-ethylhexyl) phihalate	117817	J 10	NR)J	B 13	N/A	12	13	10	1
Di-n-butylphthelate	84742	< 50	NFR	< 50	NA NA	64	120	50	•
2,4-Dimethylphenol	105670	J 71	NR.	< 50	NA NA	54	71	50	
2-Methylphenol	95497	630	2,500	< 50	NO.	206	830	50	
3/4-Methylphenol (total)	NA NA	1,200	4,500	< 50	NO.	250	1.200	50	
1Methylnaphthalene	90120	J 97	NR.	J 21	NE	46	97	19	1
2 - Methylnaphthalene	91576	160	NR NR	< 50	NF NF	68	180	28	
Naphthalese	91203	320	NA NA	< 50	N/A	52	320	22	
Phenoi	108952	4100	NR.	< 50	148	860	4.100	50	
Indene	95136	J 12	M	< 50	NET	12	12	12	1
	Total Metals - M	iethodis 6010, 700	50, 7421, 7470, 747 <u>1</u>	. aad 7641 moži	ic.				
	CAS No.	R3-H9-01	F13-H8-018	R9-H8-01		Average Coro	Maximum Conc	Minimum Cons	Comment
Aluminum	7429905	4,400.0	1,100	980.0	1,030	2,680.6	6,000.0	23.0	
Antimony	7440350	< 5.0		< 6.0	NA	97	30.0	0.3	
Amenia	7440382	5.7	0.80	< 1.0	NO	3.4	5.7	0.2	
Barium	7440393	35.0	22.9	< 20.0		292	85.0	1.0	
Calcium	7440702	76,000.0	NR.	87,000.0	16	105,500.0	200,000.0	35,000.0	
Chromium	7440473	59.0	17	2.4	3.7	139	59.0	0.1	
Cobelf	7440484	710.0	205	< 5.0	1.4	145.1	710.0	0.3	
Copper	7440508	300.0	86.1	84.0	B 95	84 1	300.0	0.7	
Iron	7439596	26,000.0	MR	720.0	NFI	5,903.2	26,000.0	26.0	
Lead	7439621	110.0	31.5	1.7	NO	227	110.0	0.0	
Magnesium	7439954	3,700.0	NA.	1,100.0	NA NA	1,316.6	3,700.0	83.0	
Mangenese	7439985	160.0	523	33.0	37	513	180.0	1.0	
Nickel	7440020	730.0	215	220.0	200	217.6	730.0	4.1	
Potassium	7440097	4,100.0	M.	< 500.9	NA	7,825.0	34,000.0	25.0	
Selenium	7782492	MD	21	ND	NO	NA.	NA.	NA	2
Godkum	7440235	8,600.0	NA	4,100.0	NF.	10,000.0	19,000.0	4,100.0	
Vanadium	7440522	16.0	2.5	< 5.0	2.9	85	18.0	0.3	
Zinc	7440666	130.0	8 39.1	7.5	4.5	317	130.0	1.1	
	TCL P Metals N	fethoris 1311.60	10, 7080, 7421, 7470	3. 7471. and 784	1 mañ				
	CAS No.	R3-H8-01	RS-H8-018	R9-H8-01		Average Coro	Maximum Conc	Minimum Conc	Comment
Aluminum	7429905		120 3000000 30000000 50 1304	< 1.00	NA NA	1.84	5.20	1.00	557-1112.112
Antimony	7440360	< 0.30	And Anna Strategy Co.	< 0.30	NA NA	0.36	0.62	0.30	
Barlum	7440393	-	1.6	ND	0.93	NA	NA	NA	2
Cadmium	7440-09		0.016	ND	NO	NA.	NA.	NA	2
Calcium	7440702	670,00	NA NA	< 25.00	NA.	529.00	2,000.00	25.00	_
Copper	7440508	< 9.13	NA.	0.73	NR.	0.29	0.73	0.13	
Iron	7439696	3.7D	Control of the Contro	< 0.50	NR	1.60	3.70	0.50	
Mangeness	7439955	0.71	A3x11.2.551503.3.x1.7.1	< 0.08	NR.	0.36	0.71	0.08	
Nickel	7440020	< 0.20	NAT	0.48	N/A	1.17	1.30	0.20	
Potasskim	7440097	153.00	200000000000000000000000000000000000000	< 25.00	NR	365.00	1,600,00	25.00	
Zino	7440866		NA	0.22	NA	0.34	0.48	0.22	
					200-11-12-1-12-11-11-11-11-11-11-11-11-11-1	3.44	2-2		

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyse not detected with EPA data, but reported with API data.

- B Analyte also detected in the associated method blank.

 J Compound's concentration is estimated. Mass spectral data indexts the presence of a compound that meets the identitios for criteria for which the result is less than the laboratory detection limit, but greater than zero.
- Reported concentration exceeds the calibration range.
 Not Datected.

- NA Not Reported, or concentration below the method detection limit

OFF-SPEC PRODUCT and FINES from THERMAL PROCESS

	Volatile Organica	- Method 8260A :	ualko						
	CAB Na.	R6-TP-01	R6-TP-018	A8A - TP - 01	RM-TP-018	Average Conc	Maximum Conc	Minimum Conc	Commente
Benzene	71432			< 25	J 200	457	1.500	5	001111101113
n-Butvitenzene	04518	< 5	NA	82	< 250	593		5	
Ethylbenzene	100414	< 5	NR		< 250	352	_,	5	
p – (sopropytokuene	99676	< 5	NA	J 38	< 250	388		5	
Methylene chloride	75092	ND.	J	ND	BJ 160	NA.	NA.	NA.	2
n-Propybenzene	103651	< 5	NA	< 25	< 250	417	1,200	5	
Toluene	108883	< 5	870	J 19	J 950	683	2,800	5	
1,2,4—Trimethylbenzene	95636	< 5	NA	270	J 250	1,631	8,200	5	
1,3,5 - Trimethylbenzene	108678	< 5	NR	140	J 140	721	2,900	5	
o-Xylene	95470	< 5	NA	63	J 130	640	2,500	5	
m,p - Xylenes	108383 / 108423	< 5	J 200	93	J 320	624	3,200	5	
Naphthalene	01203	< 5	600 0	270	J 350	1,030	3,800	5	
				-					
	CAS No.	genica — Methode R6—TP—01	1311 and 8250A RS-TP-018		R64+TP018	Average Cong	Maximum Conc	Minimum Conc	Comments
Benzene	71432	ND ND	NA	i rican i i i i i i i i i i i i i i i i i i i	250	AV SUBSTITUTE	NA NA	NA.	2
Mathylens chloride	75092	< 50	2007/03/07/05/07/07	< 50	NR.	140			-
Methyl ethyl ketone	78933		NA		NA	83	4		
meanths anily transfer	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1 00	::0:00:00:00:00:00:00:00:00	7 00	50000000000000000000000000000000000000		, 200	301	
	Semivolatile Orga	inics - Method 8	2708 μg/kg						
	CAS No.	R6-TP-01	A6-TP015	RBA -TP-01	RM-TP-018	Average Conc	Maximum Conc	Minimum Conc	Comments
Acenaphthane	83329	< 825	0.000	< 4,125		2,595	11,000	165	
Anthracene	120127	1,900	**************************************		J 1,600	2,661	₽,400	165	
Benz(s)anthracene	\$6553	28,000	15,000	8,700	4,800	11,978	1 '	165	
Benzoliuoranthene (total)	NA.	28,000	13,000			9,028		165	
Benzo(g,h,i) perylene	191242	21,000	7,000	19,000	12,000	0,344	, ,	165	
Велго(а)ругеле	50328	33,000	14,000	13,000	8,400	11,628	33,000	165	
bis(2—Bhythexyl)phtheiste	117817	1	100000000000000000000000000000000000000	< 4,125		16,349	97,000	165	
Carbazola	85748	5,900		- •	500 60 00 00 00 00 00 00 00 00 00 00 00 0	3,256	5,900	330	1
Chrystene	218019	65,000	31,000	11,000	5,300	24,028	55,000	165	
Dibenz(e,h) anthracene	53703	14,000	5,700		PARTY TO CANADA SERVICE AND A	4,532	1	165	
Dibanzoturan	132649	< 825				2,228	1 '	165	
7,12-Dimethylbenz(ajanthracene	57976	< 825	1000010001000100010000000000	< 4,125			1,200	165	1
Fluorenthene	200440	3,600	2,600		- 1 6000 0 0000 0 0000 0 1 000 0 0 1 0 0 0 0	2,565	,	165	
Fluorene	86737	7 800	The state of the s	< 4,125		3,462	1	185	
indeno(1,2,3 - ca) pyrene	193395	6,200	2,800		2/900m/0mg/0mg/m0/mm/mm	3,008	1 .	165	
Phenanthrene	85018	10,000	5,800		4,600	13,611	58,000	185	
Pyrene	1290000	27,000	11,000	14,000	6,800	10,011	27,000	105	
1 - McChylnaphthalene	90120	J 890	2000 1000 1000 1000 1000 1000 1000 1000			10,858	58,000	330	
2 - Mathylnaphthalene	91576	3,400	2,200		7,000	17,094	39,000	165	
2 - Mathylchrysene	3351324	25,000	NA		NR .	10,422	}	330	
Naphthalene	91 203	3,100	2,000	j 2,900	J 2,800	3,611	12,000	165	

OFF-SPEC PRODUCT and FINES from THERMAL PROCESS

Di b. d.d. babalaha
Di-n-butylphthalate
Benz(a) anthraceme
Benzo(a)p _i rene
Bis(2-ethyihexyl) phthelate
Chrysene
2 – Methylchrysene
i – Methylnephthalene
2 – Mathylnaphthalene
Phenol

Aluminum
Barkum
Berylium
Chromium
Cobalt
Copper
Iron
Lead
Manganese
Mercury
Molybdenum
Nickel
Selenium
Zinc

Barlum Iron LEAD Zinc

CAS No.		R8-TP-01	A6-TP-018		RO-TP-018	Average Conc	Maximum Conc.	Minimum Conc	Comments
# 4742		14	NA	< 50	NA	41	50	14	
56553		50	PA		NA NA	13	13	13	1
50326		50	NR		NR.	10	10	10	1
117817	<	50	NR	230	NR	75	230	20	
218019	<	50	ment of the control of the control of the		NA	36	35	35	1
3351324	<	100	NR		NA	15	15	15	1
\$ 0120	<	100	NR	< 100	· NA	21	21	21	1
P1 576	<	50	NR	< 50	NA NA	23	23	23	1
198952	JB	17	NR	< 50	NA	17	17	17	1
n) 64 at ala — 88	. حاضم	anto 7040), 7421, 7476, 74	76 and 704 m	alka				
ÇAS No.	CEL I I	P6-TP-01	R6-TP-018	RBA-TP-01		Average Conc	Maximum Conc	Minimum Conc	Comments
7429905		64.0	52	87.0	98,2	56.8	190.0	20.0	
7440393		ND	6.5	, ND	4.8	NA NA	NA.	NA	2
7440417		ND	NR	ND	0.22	NA.	NA.	NA	2
7440473	<	1.0	NA NA	< 1.0	1.6	1.3	3.0	1.0	
7440484		NO	1.8	ΦM	2.8	NA.	NA.	NA.	2
7440508	<	2.5	NA NA	< 2.5	< 1,0	4.7	13.0	2.5	
7439898		230.0	NA	120.0	NR	275.D	800.0	10.0	
7439921		2.5	NR.	0.8	0.65	1.5	3.7	0.3	
7439965	<	1.5	1,5	< 1.5	1.6	2.4	7.0	1.5	
7439076	<	0.05	NR	< 0.05	< 0.05	0.05	0.10	0.1	
7439987		NO	NR	ND	26.6	NA.	NA.	NA	2
7440020		40.0	17.2	12.0	20.0	39.3	120.0	8.5	
7782492	<	0.5	NA	< 0.5	< Q.8	0.7	1.4	0.5	
7440822		61.0	34.5	70.0	197	109.5	310.0	26.0	
7440868		7.8	5.9	7.5	7.2	9.5	20.0	2.0	
P Metala - N	leth	ods 1311, 601	0, 7080, 7421, 74	170, 7471, and 7	841 mg/_				
CAS No.		R6-TP-01	A6-17-018	R8A-TP-01	RBA-1P-018	Average Conc	Maximum Conc	Minimum Conc	Comments
7440393		ND	0.38	ND	0.07	NA	NA NA	NA	2
7439898	<	0.50	NA	< 0.50	N/A	0.65	1.40	0.50	
7439921	<	0.015	NR	< 0.015	< 0.025	0.02	0.03	0.02	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyte not detected with EPA data, but reported with API data.

Notes:

- B Analyte also datected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.
- NR Not Reported, or concentration below the method detection ilmit.

BPENT CAUSTIC from LIQUID TREATING

		/olatile Organics		u g/ L											
	CAS No.	73-LT-01	R3-LT-018	R3-LT-02	R3-LT-028	R0-L1-01	R6-LT-018	#13-LT-01	R13-LT-018	Average Cong I	Maximum Conc	Minimum Cong	Comments		
Acetone	67641	15,000	10,000	< 500]	NO <	\$,000	NO.	390,000 E		89.542	390,000	50			
Senzane	71432	J 90	NC.	< 500	NO <	5,000 J	2,600	420 J	440	652	2,200	50	1		
n-Bulyibenzene	104518	ND	J 240	ND	NO.	ND J	4,500	NO	NO	NA	NA	NA	2		
sec-Bulybenzene	135988	NO	NC NC	NO	NO NO	NO.	3,700	NO	NO	NA	NA	NA.	2		
Carbon disulfide	75150	< 500	NF.	1,400	NA C	5,000	MR	< 250	NR.	540	1,400	50	1		
Ethylbenzene	100414	J 710	J 390	< 500	NO	11,000	6,500	840 J	800	2,272	11,000	50	•		
Isopropyllienzane	96526	ND	NC	ND.	NO	NO.	3,300	ND	NO	NA	NA	NA	2		
p - I soproyitoluens	99876	NO	J 190	ND	ND	NO.	4,200	NO.	NO	NA	NA	NA	2		
n-Propylenzene	103651	J 660	J 350	< 500	ND <	5,000	B,800 .	360	1,700	215	360	50	-		
Toluene	108683	J 740	J 450 .	1 200	J 100	21,000	19,000	920 J	1,100	4,485	21,000	50			
1,2,4-Trimetrylbenzene	P5636	8,500	5,500	< 500	ND	51,000	44,000	2,200	2,300	10,534	\$1,000	50			
1,3,5~Trimetaribenzana	108678	1,600	1,100	< 500	ND	20,000	18,000	740 J	720	3,808	20,000	50			
o-Xylene	95476	2,500	1,400	< 500	NO	21,000	18,000	1,500	1,600	4,423	21,000	50			
m.p-Xvienes	108383 / 106423	4,000	980 .	1 220	NO	49,000	21,000	3,000	1,400	9.778	49,000	50			
Methylene chloride	75092	NOIS	J 160	NO 6	3.5 180	ND:	NO	ND	NO	NA	NA	NA	2		
Methyl ethyl katona	78933	5,600	MA	574	NA	11,000	NR.	1,400	NA NA	3,653	11,000	50	-		
Nachthalena	91203	2,900	3,200	< 500	ND ND	29,000	28,000	7,800	11,000	7,025	29,000	50			
4-Methyl-2-pentanone	108101	< 500	NA	< 500	MA <	5,000	NR.	760	NR.	400	780	50	1		
Strone		< 500	NA		18		NR.	3,300	NA NA	970	3,306	50	i		
	Semvolatile Organics — Method 62708 µg/L														
	CA3 No.	R3-LT-01	R\$LT018	R3LT02	R3LT-028	R6-L1-01	R6-LT-018	H13-LT-01	#13-LT-018	Average Conc. I	laximum Conc	Minimum Conc	Соппель		
2,4-Dimethylphenoj	105670	2,570,000	1 2,300,000	34,000	J 8,600	340,000	250,000	E 450,000 E	890,000	615,963	2,570,000	1,900			
Fluorenthena	208440	NO	NO	ND	ND	NO.	1,500	NO	NO.	NA	NA.	NA	2		
Indene	R5136	< 50,000	NA.	< 25,000	NA <	1,250	MR.	5,600	NA)	2,483	5,800	400	*		
Isophorons	78501	< 50,000	NR.	< 25,000	NR <	1,250	NR.	18,000	NR NR	5,975	16,000	400	1		
2-Methylphanol	95487	\$2,400,000	E 22,000,000	229,000	E 130000	94,000	120,000	E 150,000 E	1,300,000	5,797,433	32,400,000	9,500			
3/4 - Methylphenol	HA	\$4,600,000	E 37,000,000	510,000	E 340,000	170,000	240,000	77,000 E	1,500,000	10,144,350	54,500,000	9,100			
Pentachlorophenol	47865	ND.	NO	NO.	NO.	NO.	1.300	NO	NO.	NA	NA.	NA	2		
Phensnihune	85018	ND	NO	ND	NO.	NO	14,000	NO	ND.	NA	NA	NA	2		
Phenol	108952	92,600,000	E 55,000,000	1,600,000	E 1,600,000	24,006		5,100	630,000	19,372,933	92,500,000	\$,100			
Benzenethol:	108985	£,130,000	NO	6,070,000	750007 <	2,500	NO.	4,400	540,000	1,434,550	0,070,000	400			
1 – Meitylaephthalane	90120	< 100,000	NO	< 50,000	ND ND	33,000	41,000	< 3,425	NO	10,606	33,000	800	1		
2-Methylnephthelene	91570	< 50,000	NĐ	< 25,000	ND ND	22,000	55,000	< 1,713	ND	7,203	22,000	400	1		
Naphthalene	91203	< 50.000	NO	< 25,000	ND	26,008	31,000	15,000 J	13,000	13,960	26,000	400	1		

SPENT CAUSTIC from LIQUID TREATING

	Total Metale - Me	thods 6010, 70	80, 7421, 7470, 747	71, and 784 1 m	g/L								
	CAS No.	R0-LT-01	R9-LT-018	A3-LT-02	R3+LT+028	R0-LT-01	R6LT018	R13-LT-01	R15-LT-018	Average Conc	Madmum Conc	Minimum Conc	Comments
Aluminum	1429905	NO	25	ND	13	NO	NO.	ND	NO	NA.	NA	NA	2
Arsenio	7440382	26.00	23.7	5.00	5 •	< 0.10	0.01	< 0.10	ND	5.62	26.00	0.10	
Chromium	7440473	< 0.005	MA .	< 0.005	NR ·	< 0.005	NA.		NA.	0.008	0.015	0.005	
Cobali	7440484		123	< 0.25	•	< 0.25	ND ND		ND	4.04	23.00	0.25	
Copper	7440508	< 0.013	M	< 0.013	NA ·	C1Q0 >	NA.	< 0.013	NF3	0.025	0.087	0.013	
Iron	7439898	< 0.05	₩ ·	< 0.05	NA .		MAI.		NF)	4.23	24.00	0.05	
Lead	7439921	0.27	NB NB	0,12	NA .		NA.	< 0.03	NF.	0.09	0.27	0.03	
Manganesa	7439965	< 0.008	MA	< 0.008	MR ·	0.008	NA .	< 0.008	NA	0.009	0.016	0.008	
Mercusy	7439976	0.270	NO.	< 0.005	NO ·	< 0.005	ND .	< 0.005	0.00084	0.093	0.270	0.005	
Potaselum	7440097	< 2.50	NA NA	< 2.50	NA ·	< 2.50	NR.	< 2.50	NA	52.08	300.00	2.50	
Selentum	7782492	0.35	NA NA	0.08	NF -	< 0.03	NA.	< 0.03	NA NA	0.11	0.35	0.01	
Sodium	7440235	110,000	NR.	43,000	NA NA	12,000	NA.	38,000	NA NA		110,000	12,000	
Theillen	7440280	< 9.05	NR ·	< 0.05	NR ·	< 0.05	NR	< 0.05	NR	9.11	0.38	0.05	
Zina	7440665	< 0.01	B \$8	< 0.01	В \$	0.44	0.029	< 0.01	NO	0.09	0.44	0.01	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyte not detected with EPA date, but reported with API date.

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral deta Indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory distriction limit, but greater than zero.
- E Concentration exceeds the upper published on standard.
- ND Not Detected.
- NA Not Applicable
- NR Not Reported, or concentration below the method detection limit

SULFUR COMPLEX BLUDGE

	Volatile Organica	- Method 8260A	μα/κα							
	CAS No.	R1-ME-01	R1-ME-018		R6-ME-01	FIS-ME-018	Average Cono	Maximum Conc	Minimum Canc	Comments
Acetone	67641	8,600	NR	<	1,250	NA NA	1,834	6,600	25	
Benzene	71492	< 2,500	J 360	<	1,250	NO.	260	420	99	1
n-Butribenzane	104518	7,200	1,200	J	700	NO	1,830	7,200	25	
Carbon disulfide	75150		NA	<	1,250	NR	120	120	120	1
Etylberzene	100114	9,600	3,400	J	1,100	NO	2,421	9,500	180	
Isopropylterzene	98428	NO	810		ND	NO	NA.	NA.	NA	2
p – leapropylitaiuen e	99176	NO	J 480		ND	NO	NA.	NA	AM.	2
4-Mathyl-2-penianone	108101	78,000	NA.	<	1,250	NA.	16,100	76,000	25	
Methylene chiaride	75002	< 2,500	BJ 200	<	1,250	j 220	. 56	150	25	1
n-Propybenzere	103651	5,600	1,800	<	1,250	NO	1,820	6,600	25	
Tolume	108683	13,000	5,600	J	510		3,003	13,000	260	
1,2,4 - Trimethytoenzene	95636	47,000	16,000	Ĵ	1,500	NO	10,082	47,000	310	
1.3.5 - Trimethy/benzene	106478	16,000	5,000		520	NO.	3,620	16,000	400	
o-Xylene	95476	16,000	6,500	₹	1,250	NO	3,727	16,000	150	
m.p.—Xylenes	106363 / 106423	54,000	8,600	L	1.000	NO.	11,374	54,000	480	
Naphthelene	91203				2,500	J 120	7,537	34,000	25	
(Separation)				•	_,,		-,		•	
	TCLP Votable On	renice – Mathodi	1311 and 8260A	ac.	ι,					
	CAS No.	Rt-ME-01	R1-ME-018		R6-ME-01	PS-ME-018	Average Cono	Maximum Cono	Minimum Conc	Comments
Acatona	67641		NR	۱ <	50	NA.	96	180	50	
Benzene	71432		50	~	1	NO	26	26	26	1
Ethylberzene	100414	130	NR.	-		NE	65	130	50	
Methylane chłode	75092		NA.	٦,		N/A	24	24	24	1
Toluene	108683	500	NA		440	NA	218	500	50	
1,2,4 Trimethylibertzene	95636	210	NR	L	23	NA	77	210	23	
o-Xviena	95476	260	NR.	ľ	210	NA	124	260	50	
m.p.—Xylene	108383 / 108423		NA.		340	NR	224	630	50	
Naphthalma	91203				49	NR	32		14	1
) and a committee	1	,			,				•	
	Semivolatile Oro	anics Method &	270B uaka							
	CAS No.	R1-ME-G1	R1-ME-018		FB-ME-01	18-ME-018	Average Cono	Medimum Cono	Minimum Conc	Comments.
Acenaphtene	83329	J 7,800	J 19,000	۱ <	16,500	NO	3,332	7,800	165	1
Arthragane	120127	1 6,000	NR.	۱ <	16,600	NF3	2,361	5,000	165	1
Chrysene	218019	< 6,800	NP.	۱ <	10,500	NR	1,383	2.600	105	1
Dibenzokum	132649		NR	<	16,500	NR.	1,033	1,900	165	1
Fluorene	66737	J 0,700	NR	۱ <	16,500	NR	5,100	8,700	165	1
leaphorane	78501	J 0,700	NA NA	۱ ،	16,500	NA	3,165	6,700	600	1
2 Mathylchnysene	3351324	< 11,200	NA NA	<	33,000	NR	885	1,400	330	1
1 - Mathylnaphthalane	90120			١ <	33,000	ND	25,666	39,000	330	
2 Metryingshithelene	91576				18,500	NO	38,206	87,000	530	
Nachthalana	91203					NO	9,945	18,000	165	
Phenenthorse	85018					NO	12,270		580	
Pyrene	129000					NO	3,491		105	1
· year		,,000		, ,			-,			

BULFUR COMPLEX SLUDGE

	70100			TO					
	TCUP Samivolatile C CAS No.	Jigamics – seens Ri–ME−0l	R1+ME+018	.ε. μαχ 185−ΜΕ01	RG-ME-018	Average Comp	Maximum Cono	Minimum Cono	Comments
B - 44	50328 JB		NA NA	- 1	1941	St.	18		1
Benzo(e)pyrene		1 10 Bub	NR .		NA	1		18	•
Bis(2-ethythexyl) phthalate	117817 J	1			200000000000000000000000000000000000000	66	96	50	
DI-n-butyl phthafale	64742 <	- 1	NR JE		鞭	40	74	12	
t - Mothylnaphthalene	90120 J	70		100	N#1	39	76	18	1
2 - Methymaphthalene	91576 J		. March 61 (000,000)	50	NA.	54	94	17	
3/4 - Methylphanol (fotel)	NA <		J 59 4		NO	53	65	50	
Nephthelene	91203 J	Q 3	NA ·		NA	57	93	42	
Phenanthrene	85018 J	12	NR -		N/FI	12	12	12	1
Phenot	108952 <	50	NA .	c 50	NA)	74	170	50	
	Total Mateia - Mat	orfo 6010 7060	7491 7470 7471	and TREE made	~				
	CAS No.	F11-ME-01	R1-ME-018	Ro-ME-01	NE-ME-018	Avererse Cono	Medmum Cano	Minimum Cana	Comments
Aliminum	7429905	230.0		20.0	22.2	876.0	3,600.0	20.0	
Antimony	7440360 <	3	ND	14.0	70	13.4	35.0	6.0	
Arrenic	7440382	33.0	58.5	17.0	17.8	34.4	120.0	1.0	
Barlum	7440393	NO.	10.1	NO	1,2	NA.	NA.	NA NA	2
Cadrolum	7440439	1.1	NR -		NA	1.2	9.3	0.5	-
Calclum	7440702	7.700.0	NR 3	1	NF.	8.040.6	14,000.0	500.0	
	7440473	270.0		18.0		245.6	900.0		
Ohromkim Ohrom			442		12.5			18.0	
Cabell	7440484	11.0	12.1		2.0	16.8	39.0	5.0	
Copper	7440508	87.0	111	01.0	62.4	96.0	150.0	78.0	
kon	7409898	170,000.0	NR	28,000.0	NA NA	105,600.0	220,000.0	26,000.0	
Leed	7439921 <	- 1	NR -			1.0	2.7	0.3	
Magnanium	7430054	2,300.0	NA -		141	990.0	2,300.0	500.0	
Manganasa	7439965	1,800.9	2,550	270.0	194	846.0	1,600.0	180.0	
Molybdanum	7439987	10.0	24.5		4.6	21.5	64.0	6.5	
Nickel	7440020	60.0	79.3	60.0	44.3	225.8	750.0	19.0	
Selenium	7762492	140.0	213	9.5	9.1	270.3	1,200.0	0.5	
Sodum	7440235	51,000.0	NR <		₩A	13,700.0	61,000.0	500.0	
Vanadism	7440622	38.9	11.6		NO	14.6	38.0	5.0	
Zhe	7440668	39.0	47.3	35.0	24.4	37.2	58.0	10.0	
	}								
	TCLP Metals - Not	hode 1311, 6010	7060, 7421, 7470	, 7471, and 784					
	CAS No.	R1-ME-01	R1-ME-018	FIG-ME-01	R6-ME-018	Average Conc	Madeium Conc	Minimum Cano	Comments
Arsenic	7440382 <	0.05	NA	0.49	NR.	0.14	0.49	0.05	
Berlum	7440393 <	1.00	0,11	2.70	0.86	1.34	2.70	1.00	
Calcium	7440439	51.00	NA •	25.00	NA NA	132.20	400.00	25.00	
Chromium	7440473 <	0.05	0.13	0.12	0.12	0.06	0.12	0.05	
Coball	7440484 <	0.25	NF <	0.25	NA NA	0.38	0.01	0.25	
Copper	7440508 <	0.13	NR	0.43	NA	0.18	0.41	0.13	
Iton	7439898	260.00	NR	67 0 00	NA	298.00	570.00	130.00	
l,ead	7439921 <	0.02	NO	1.10	0.053	0.25	1.10	0.02	
Manganese	7439965	36.00	NR	11.00	NA	13.42	36.00	2.00	
Nickel	7440020 <	0.20	NR	2.50	NA.	2.00	5.90	0.20	
Salentum	7782492 <	0.03	NR •	< 0.03	NA	0.04	0.12	0.03	
Zinc .	7440668 <	0.10	NR	2,40	NA.	1.00	2.40	0.10	
						,	,	101	

Communis:

- Detection finite greater than the highest detected concentration are excluded from the calculations.
 Analyte not detected with EPA data, but reported with AP data.

Notes:

- 4. Analyte also detected in the associated method blank.
 J. Compound's concentration is estimated. Mean spectral data indicate the presence of acompound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Delected.
- NA Not Applicable.
- NR. Not Reported, or concentration below themsehod detection limit.

CLAUS CATALYST from SULFUR COMPLEX

	Volatile Organics -	- Method 8260	A uaika						
	CAS No.	R1-SC-01		R4-SC-01	R4-SC-01S	Average Conc	Maximum Conc	Minimum Conc	Comments
Acetone	67641	2,500	 A Contract Apparent Contract Contract Contract 	,	79	873	2,500	20	2 2 3 3 3 7 3 7 3 2
Acetonitrie	75058	< 625	NA NA	21	NA	21	21	20	1
Benzene	71432	NE		ND	J 2.3	NA	NA.	NA NA	2
tert - Butylbenzene	98066	NE		ND	NO	NA	NA NA	NA	2
Carbon disulfide	751 5 0	NE		ND		NA	NA.	NA	2
Ethylbenzene	100414	NC		ND	ND	NA	NA.	NA	2
n-Propybenzene	103651	NE		ND	NO	NA	NA	NA	2
Taluene	108883	< 625			J 4.8	93	180	5	1
1,2,4 - Trimethylbenzene	95636	2,600			ND	875	2,600	5	
1,3,5 – Trimethylbenzane	108676	NE			DN	NA	NA	NA	2
Methylene chloride	75092		BJ 280			NA	NA.	NA	2
Methyl ethyl ketone	78933	1,400		1	NR	486	1,400	20	
Naphthalene	91203	17,000			J 1.5	5,675	17,000	5	
oXylene	95476	NC				NA	NA	NA	2
m.pXylenes	108383/106423	NC	J 490	ND	J 1.6	NA	NA	NA	2
	TCLP Volatile Orga	anics - Metho	is 1311 and 8260A	ua/L					
	CAS No.	R1-SC-01			R4SC018	Average Conc	Meximum Conc	Minimum Cooc	Comments
Acetone	67841	840			NR	313	840	50	00//////
Acetanitrile	75058	< 50	NR	100	NR	67	100	50	
Benzene	71432	NO	ND	ND	J 10	NA	NA	NA	2
Methylene chloride	75092	< 50	NR	< 50	NA	77	130	50	
Naphthalens	91203	160	NR	< 50	NR	67	160	50	
	Semivolatile Organ	uha Madhad	9770D walke						
	CAS No.	R1 - SC - 01		R4-SC-01	D4 00 010	A	Maximum Conc	Minimum Conc	0
Di-n-butyl phthalate	84742	< 330			MA-SC-UIS NR				Comments
2 – Methylnaphthalens	91576	J 240			NA ND	235 190	330 240	165 165	
Naphthalene	91203	4,200	4 ASSES GASTAL PROPERTY MANAGEMENT AND AND		ND ON	1,510	4.200	165	
1 - Methylnaphthatens	90120	J 200			ND ND	1,510 200	4,200 200	200	
Chysene	218019	J 68	0000 000000000000000000000	;	NR	- 68	200 68	68	1
Fluorenthene	206440	1.000		480	550	548	1,000	165	•
Phenanttrene	85018	2,800	0,00,000,000,000,000	670	790	1,212	2,800	165	
Pyrane	129000				ND	277	500	165	
							,		
			ethods 1311 and 82		<u> 1880 (1880 - 1888) (1880 - 1</u>				_
Bis (2 ethylhexyl)phthalate	CAS No. 117817	Rt -SC-01	 AZ9949Z1Z99693Z5G 				Meximum Conc		Comments
Di-n-butyl phthalate	1	960	1 Control of the Cont	- 1	NA	359	960	16	_
Naphthalene	84742 91203	< 50 J 88			NA	12	12	12	1
Phenol	108952		Q/3/10000 400000000000000000000000000000000	;	NR NR	62	86	50	_
1 A POLITICAL	100905	- 50	NR NR	< 50	NR NR	14	14	14	1

CLAUS CATALYST from SULFUR COMPLEX

Aluminum Arsenic Berylllum Calcium Iron Manganese Selenium Sodium Zinc

Aluminum Barlum Calcium Iron Manganese Zinc

CAS No.	R1-SC-01	R1-8C-018	R4-SC-01	R4-SC-015	Average Conc	Maximum Conc	Minimum Conc	Comments
7429905	150,000	61,500	260,000	78,200	180,000.0		130,000.0	
7440382	13.0	NR	< 5.0	NR	9.3	13.0	5.0	
7440417	1.3	0,6	< 1.0	0.58	0.9	1.3	0.5	
7440702	< 500.0	NR	22,000.0	NR	7,666.7	22,000.0	500.0	
7439896	130.0	NR	71.0	NR	140.3	220.0	71.0	
7439965	ND	7.3	ND	38	NA	NA NA	NA	2
7782492	< 0.5	NE	< 2.5	NR	1.1	1.7	0.5	1
7440235	2,400.0	NR	< 1,000.0	NR.	1,700.0	2,400.0	1,000.0	
7440666	25.0	49.4	54.0	200000000000000000000000000000000000000			1.	
. ,	20,01	16.2	51.0	23.2	28.7	51.0	10.0	
	•	10,21), 7060, 7421, 747 R1—SC—018	•	341 mg/L		·		Comments
iletzis – Me	thods 1311, 6010), 7 060, 7421, 747	70, 7471, and 7	341 mg/L		Maximum Conc		Comments
fetzis Me CAS No.	thads 1311, 6010 R1-SC-01), 7060, 7421, 747 R1—9C—018	70, 7471, and 70 R4-SC-01	341 mg/L R4~SC~01S	Average Conc	Meximum Conc	Minimum Conc	Comments
Metals - Me CAS No. 7429905	thods 1311, 6010 R1 - SC - 01 18,00 ND), 7060, 7421, 747 R1—SC—015 NR	70, 7471, and 70 R4-SC-01 110.00	841 mg/L R4-SC-01S NR	Average Conc 58.67	Maximum Conc 110.00	Minimum Conc 18.0	
fetzis Me CAS No. 7429905 7440393	thods 1311, 6010 R1 - SC - 01 18,00 ND), 7060, 7421, 747 R1—SC—01S NR 0.027	70, 7471, and 70 R4-SC-01 110.00 ND	841 mg/L R4-SC-01S NR ND	Average Conc 58.67 NA	Maximum Conc 110.00 NA	Minimum Conc 18.0 NA	
Aetzis - Me CAS No. 7429905 7440393 7440702	thods 1311, 6010 R1 - SC - 01 18.00 ND < 25.00), 7060, 7421, 747 R1-9C-01S NR 0.027 NR	70, 7471, and 70 R4SC-01 110.00 ND 840.00	941 mg/L R4-SC-01S NR ND NR	Average Conc 58.67 NA 230.00	Meximum Conc 110.00 NA 640.00	Minimum Conc 18.0 NA 25.0	

Comments:

- 1 Detection limits greater than the highest detected concentration are excluded from the calculations.
- 2 Analyte not detacted with EPA data, but reported with API data.

Notes:

- B Analyte also detected in the associated method blank.
- J Compound's concentration is estimated. Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
- ND Not Detected.
- NA Not Applicable.
- NR Not Reported, or concentration below the method detection limit.

APPENDIX C

Summary of Runon/Runoff Information for

Crude Oil and CSO Sediments

Runon/Runoff Controls for Land Treatment Units

Crude Oil Tank Bottom Sludge (18 onsite LTUs)

Severity of the storm event that the unit's runon/runoff control system is designed to protect against:

25 yr	<u>50 yr</u>	<u>100 yr</u>	No response
6	1	8	3

Type of runon/runoff control system in place (more than one may apply):

Berms to prevent water running onto the unit	10
Berms to prevent water running off the unit	10
Berms to prevent flood water from reaching the unit	2
Dikes to prevent water running onto the unit	6
Dikes to prevent water running off the unit	7
Dikes to prevent flood water from reaching the unit	4
Diversion ditches to prevent water running onto the unit	2
Diversion ditches to prevent water running off the unit	3
Diversion ditches to prevent flood water from reaching the unit	0

Where is runoff sent:

Onsite WWTP	11
Offsite WWTP	1
Evaporation Pond	1
No runoff	2
No response	3

Stormwater control

- 16 say that contact with stormwater is possible; 2 say it is not possible. These One facility says that contact is not possible due to a 3 foot berm around the unit. One facility says that contact is not possible due to dikes around the unit which routes stormwater to the wastewater treatment plant. This facility also did not respond to the remainder of the questions in the table, accounting for most of the "no responses" that follow.
- 9 of 18 manage their stormwater under a permit.

• 13 are not in floodplains, 1 is in a 500 year floodplain, 1 is in a 400 year floodplain, 2 are in a 100 year floodplain, and 1 did not respond to this question.

Distance to nearest downgradient waterbody:

< 1/4 mile	6
1/4-1/2 mile	4
1/2-3/4 mile	2
3/4-1 mile	1
>1 mile	3
No response:	2

Water body names and details on surface water monitoring (e.g., data, reason for monitoring) are provided, but are not included in this report.

Features affecting movement of surface water between unit and water body: 15 have such features, 2 do not, 1 provided no response.

CSO Sludge (9 onsite LTUs)

Severity of the storm event that the unit's runon/runoff control system is designed to protect against:

<u>25 γτ</u>	<u>50 yr</u>	<u>100 yr</u>	No response
3	1	4	1

Type of runon/runoff control system in place (more than one may apply):

Berms to prevent water running onto the unit	6
Berms to prevent water running off the unit	6
Berms to prevent flood water from reaching the unit	1
Dikes to prevent water running onto the unit	2
Dikes to prevent water running off the unit	3
Dikes to prevent flood water from reaching the unit	2
Diversion ditches to prevent water running onto the unit	1
Diversion ditches to prevent water running off the unit	1
Diversion ditches to prevent flood water from reaching the unit	0
No response	1

Where is runoff sent:

Onsite WWTP	5
Offsite WWTP	1
Evaporation Pond	1
No runoff	1
No response	1

Stormwater control

- All 9 say that contact with stormwater is possible.
- 5 of 9 manage their stormwater under a permit.
- 7 are not in floodplains, 1 is in a 500 year floodplain, and 1 is in a 100 year floodplain.

Distance to nearest downgradient waterbody:

< 1/4 mile	2
1/4-1/2 mile	3
1/2-3/4 mile	1
3/4-1 mile	2
> 1 mile	1

Water body names and details on surface water monitoring (e.g., data, reason for monitoring) are provided, but are not provided in this report.

Features affecting movement of surface water between unit and water body: 8 have such features, 1 does not.